Differential Convergence Education from Pluridisciplinarity to Transdisciplinarity

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Abstract

Convergence, the process of bringing together traditionally distinct disciplines for creative and innovative purposes in various aspects of life, is nowadays a sweeping reality in the job market, professional R&D organizations, and new majors and departments at prominent universities around the globe. Educational institutions of all levels should follow suit, including K-12 general education. Differential convergence is hereby proposed with five modalities that can be accommodated in any educational system, like in any non-educational sector, including traditional discipline-based systems. Modalities distinguished in terms of specific theoretical and practical criteria are, in increasing order of cohesiveness and productivity, pluridisciplinarity, multidisciplinarity, interdisciplinarity, crossdisciplinarity, and transdisciplinarity. These modalities, like discipline-based curricula, become particularly efficient when designed and implemented under systemic theoretical/pedagogical frameworks that consider the physical world around us, as well as the conceptual realm of our thoughts and academic disciplines, to consist of well-defined systems. Convergence in education is thus hereby advocated as systemic differential convergence education, with crossdisciplinarity and transdisciplinarity to be gradually attained in secondary and tertiary education respectively.

Keywords

Convergence, crossdisciplinarity, differential convergence, discipline-based education, emergence, framework, interdisciplinarity, multidisciplinarity, paradigm, pluridisciplinarity, systemism, transcendence, transdisciplinarity

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Content

The quality of individual and community life is largely determined by the quality of knowledge a person holds and shares with others. It especially depends on how readily and efficiently one can bring together and process knowledge critically and insightfully from reliable sources in different academic and other professional fields in order to address career and life issues. Such knowledge merger, often labelled as convergence, requires particular competencies that should be the object of formal education, beginning with early schooling years and extending through higher education. This paper defines modalities of a special type of convergence, *differential convergence*, and discusses how such convergence can take place systemically in the context of traditional discipline-based curricula that still prevail in K-12 education and beyond.

Convergence, simply put, is the process of bringing together knowledge from different disciplines from the same or different fields[1] in order to address certain issue(s), be it academic, industrial, social, or of any other nature or scale. Communication devices and numerous other inventions brought to us by and along with the digital revolution are the product of such convergence, and could not come about differently, especially not from the prospect of any single discipline or field. The exponential growth of knowledge we have been experiencing lately is at least in part a consequence of new disciplines that emerge by convergence of existing disciplines. New careers that mushroomed recently in various firms around the globe, and that are expected to keep popping up exponentially in the near and distant future, require people who hold them to have unprecedented qualifications, and especially to be competent enough to uptake the convergence in question creatively and innovatively in the workplace[2].

This has led many universities and professional organizations to change the traditional course of disciplinary segregation, i.e., of operating in the realm of individual disciplines often independently from each other. Significant restructuring has taken place there lately to allow for convergence of disciplines not only from the same or close fields (e.g., science, mathematics, engineering, and technology, collectively referred to as STEM), but, more importantly, from traditionally distinct or remote fields (e.g., arts and humanities or social and economic sciences, brought together with any or all of the STEM fields).

In order to systematize and optimize convergence efforts and bring about sustainable development at the global scale, some leading international organizations like the former International Council for Science and International Social Science Council have gone into mergers. According to McBean and Martinelli (2017), presidents of the two organizations in question that merged in October 2017 into the International Science Council, the merger "will provide a new institutional context for the long-called-for convergence to become a reality". It "should help foster meaningful inter-disciplinarity that begins with the joint framing of problems; ensure that all disciplines are exploiting opportunities of the digital revolution, including for data integration; and unify scientific communities. It will be guided in its actions by the shared vision of advancing all sciences as a global public good". Other organizations had

[1]In this paper, we use the word "discipline" to refer to traditionally distinct academic domains that set apart traditional university departments like dance and music in arts, biology and physics in natural sciences, and philosophy and sociology in social sciences. A discipline is traditionally broken down into "branches" like classic and country music, classical mechanics and electrodynamics in physics, and ontology and epistemology in philosophy. In contrast to a common practice that mixes up between field and discipline, we use the world "field" to refer to a set of disciplines of close foundations and practices like arts, humanities, natural sciences, statistics, or social sciences. We finally use the word "realm" to put together related fields like arts and humanities, engineering and technology, mathematics, natural and health sciences, and social and economic sciences.

[2]See, for example, Baek, Cho, & Kim, 2019; Bement, Dutta, & Patil, 2015; Brennan et al., 2014; Choi & Pak, 2006; Hancock, Lazaroff-Puck, & Rutherford, 2020; Hart Research Associates, 2013, 2015; Karbhari, 2018; Lyall, 2019; McKinsey, 2017, 2018, 2019; NRC, 2012a & b, 2014; OECD, 2013, 2018a & b; Schleicher, 2015; UN, 2015.

long before dedicated to promoting such convergence (interdisciplinarity), or even to transcending altogether traditionally distinct disciplines. This is for example the case respectively of the US based Association for Interdisciplinary Studies (formerly Association for Integrative Studies) founded in 1979, and the France based International Center for Transdisciplinary Research and Studies (CIRET) founded in 1987.

In 2016, the National Science Foundation (NSF) in USA introduced "NSF 2026: the Integrative Foundational Fund" a research funding initiative "to transcend established scientific structures and standard operating procedures". The initiative is about "10 Big ideas for Future NSF Investment" including "Growing Convergent Research at NSF" because the "grand challenges of today -- protecting human health; understanding the food, energy, water nexus; exploring the universe at all scales -- will not be solved by one discipline alone. They require convergence: the merging of ideas, approaches and technologies from widely diverse fields of knowledge to stimulate innovation and discovery" (NSF, 2017).

In its "Moral Project", CIRET (1987) held that in "the long term it is possible to envisage the creation of a 'Transdisciplinary University'". This vision became a reality a few years later, beginning with some prominent US universities. For instance, in his 2002 inaugural address as the new President of Arizona State University (ASU), Michael Crow laid down his concept of the New American University (Crow & Dabars, 2015), and began since "fusing intellectual disciplines" and turning ASU into a "uniquely adaptive and transdisciplinary university committed to producing master learners... Unorthodox actions, like merging the departments of plant biology, microbiology and biology into a single School of Life Sciences, a truly interdisciplinary unit,... allowed scientists, economists, philosophers and others to come together to create a new and rich academic landscape, which in turn inspires students to think and learn in different ways" (ASU, 2020). ASU and a few other universities who took similar paths on various continents, and who, in the process, are reconsidering the very definition of disciplines, did so primarily because of the new realities in the job market and the conviction that:

> *Gone are the days when a college education pertained to training for a singular career path. Today, the lightning rate of discovery and technological advancements, the rapidly changing global economy and the growing need for new skills, products and services has rendered the concept of the single, lifelong career obsolete.*
>
> *ASU New Objective* (*ibid*)

Education at all levels should follow suit and allow, in practical respects related to everyday life, for convergence of knowledge from traditionally distinct educational fields and disciplines[1]. This is necessary not only for career readiness, but most importantly to improve the quality of learning in general, and especially to bring about coherence and consistency into student disciplinary knowledge. The plethora of educational research has been constantly showing in the past half century or so that students of all levels often complete and pass their traditional disciplinary or discipline-based courses with fragmented and compartmentalized knowledge of elusive utility. Students are unable to transfer what they learn in one course to another course, even in one part of a given course to another part of the same course. This evidently fails students to take enough advantage of their disciplinary knowledge in everyday life and eventually in the workplace when they get there.

General K-12 education has long been discipline-based (disciplinary hereafter), i.e., about discrete accumulation of knowledge, primarily epistemic or content knowledge, from a variety of disciplines, indeed disciplinary branches[1], traditionally separated by impenetrable barriers. Disciplinarity or disciplinary practices have always had, and will continue to have, their merits in various sectors within and outside education, including academia and related research and

development in productive sectors. According to OECD (2018b, p. 5), "disciplinary knowledge will continue to be important, as the raw material from which new knowledge is developed, together with the capacity to think across the boundaries of disciplines and 'connect the dots'". Discipline-based educational research will also continue to be needed to help students learn disciplinary knowledge meaningfully and productively (NRC, 2012c), and especially to appreciate such knowledge and recognize its merits in relation of various disciplines to each other and to everyday life (NRC, 2012a).

Many prominent organizations, especially in science education, have long been calling to "connect the dots" in student knowledge. They have promoted to this end crosscutting concepts and ideas that bring coherence within and across different disciplines, and eventually some form of convergence among disciplines in at least related fields like STEM (AAAS 1993, 1996; AAC&U, 2002; Doerr, 1996; NASEM, 2018; NRC, 1996, 2012b, 2014; NSTA, 1995). In the words of AAAS (1993, p. 261), some "important themes [e.g., patterns, systems, models, constancy and change] pervade science, mathematics, and technology and appear over and over again, whether we are looking at an ancient civilization, the human body, or a comet. They are ideas that transcend disciplinary boundaries and prove fruitful in explanation, in theory, in observation, and in design".

Educational curricula and research urgently need to heed such calls and follow the lead of many universities and productive sectors in society in engaging students in convergence education at all levels, K-12 included. In this paper, we advocate in particular what we call "differential convergence education" whereby students are purposely engaged in collective and interactive work that requires bringing together knowledge from different disciplines in systemic settings without entirely giving away disciplinary education. Notwithstanding the fact that conventional disciplinary curricula often need major overhaul, the break-up with discipline-based tradition is neither realistic nor necessary, at least not until the realities on the grounds are universally ripe and convincing enough to head in that direction.

The quality of convergence output depends not only on the knowledge brought together from different disciplines, but most importantly on the conceptual lenses that bring it about, i.e., on the theoretical framework in the context of which convergence is carried out (Fig. 1). Such convergence, as we argue in this paper, can be achieved feasibly and efficaciously through certain differential modalities under systemic frameworks, in education like elsewhere. These are frameworks set to organize knowledge in any discipline around particular systems of well-defined structure and function, and to push for systematic schemes of system design and deployment (Bunge, 1979, 1983, 2000; Halloun, 2019, 2020a; Johnson-Laird, 2006; NRC, 2012a & b; Sosa et al., 2010). Systemic Cognition and Education is such a pedagogical framework in the context of which differential convergence education is hereby proposed to take place.

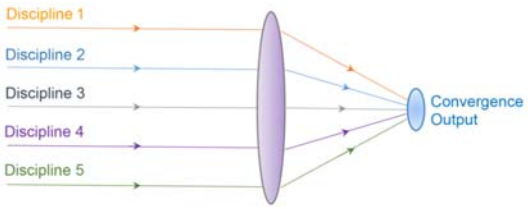

Figure 1. Convergence of knowledge from many disciplines the output of which depends on the conceptual lens, the framework, through which convergence takes place.

The paper, somewhat written with the spirit of a white paper, comes in five sections. The concept of differential convergence is introduced in the first section, and five corresponding modalities are distinguished in the second section in terms of specific criteria. These are pluri-, multi-, inter-, cross-, and trans-disciplinarity. Key aspects of these modalities are summed up in the third section. A systemic perspective on differential convergence is offered in the fourth section, along with related advantages. The paper concludes in the fifth section with educational implications for disciplinary curricula.

1. Differential convergence

Convergence is a process of putting together in specific respects knowledge from two or more disciplines in order to bring about a desired output (Fig. 1). The process engages a number of professionals from different disciplines for the purpose of tackling together a particular issue (question, problem, case study, product design or manufacture, research or development project, etc.) and bringing it to an end (desired output) that could not be brought about in the framework and confinements of a single discipline.

Knowledge drawn from any discipline often comes from one specific branch in that discipline, with each branch primarily distinguished from other branches in the same discipline by a good proportion of its episteme and methodology (its unique theory in science), and various branches in that same discipline sharing or belonging to a common paradigm[3] (Halloun, 2004/6). A given discipline is usually distinguished from other disciplines in the same field by its unique paradigm, and various disciplines in the same field have many paradigmatic aspects in common, and share, in particular, some paradigmatic premises. Paradigms start drifting apart as we move from one field to another in the same realm, but especially to different realms[1]. The reader is invited to keep these subtleties and more[1,3] in mind as we move along with our discussion of disciplinary convergence, i.e., convergence of different disciplines that may belong to the same or different fields, in the same or different realms.

Convergence we are concerned about involves, at any given instance or in any given issue, only some but not all paradigmatic premises in any given discipline, and only some but not all conceptions and procedures in any given disciplinary branch. Furthermore, such convergence requires neither full integration of disciplines nor any form of supervenience or hegemony that rebukes the merits of any discipline altogether or annihilate it through fusion with other disciplines. Convergence we are advocating is *differential* in the sense that it honors and spares the integrity and sovereignty of any discipline in all foundational (paradigmatic premises) and practical (episteme and methodology[3]) respects, while recognizing the interdependence of certain disciplines in specific respects and the possibility of any discipline to benefit from other disciplines at any time and place. Even when transcendence is required, i.e., when convergence

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[3] A *paradigm* is a complex conceptual system that governs all thoughts and actions of a given individual or, especially, of a given community (group of people, especially professionals, working for common goals). Every professional community, and especially academic community, is characterized by one particular paradigm that governs everything this community does (or a couple of complementary paradigms, like the classical and modern paradigms of natural sciences). The paradigm consists then primarily of:

- ontological, epistemological, methodological, and axiological (ethics and value system included) tenets of axiomatic nature, corroborated principles, and other foundational propositions commonly accepted by all members of the concerned community and hereby collectively referred to as *paradigmatic premises*;
- an *episteme*, or conceptual or content knowledge, that consists of a repertoire of *conceptions*, i.e., concepts, laws, theorems, and other relationships among concepts, and related semantics and syntax (all of which being coherently organized in and around conceptual models in corroborated theories in science, with each disciplinary branch exclusively characterized by one particular *scientific theory*);
- a *methodology*, or repertoire of procedural knowledge, that consists of a repertoire of mental and sensorimotor *procedures* of specific rules and guidelines, along with necessary tools and resources chosen or developed in accordance with specific norms and standards.

Paradigmatic premises govern the inception of conceptual and procedural knowledge for serving specific purposes, as well as the corroboration, deployment, and continuous evaluation and regulation of such knowledge, and thus of the paradigm altogether. Because of their generic nature, some, if not most of these premises often cut across different disciplines in the same field or even different fields in the same realm[1]. Disciplines in the same field would then be distinguished more by their episteme and some of their procedures (theories in science) than by their premises. That is why the word "paradigm" is often reserved in the literature to refer exclusively to paradigmatic premises within the same discipline or the same field, without including episteme and methodology.

needs to go beyond disciplinary boundaries into novel paradigmatic territories not ventured before, it is achieved not to the detriment of any discipline, but by widening horizons and opening new doors in ways which existing disciplines may benefit of. This is especially true in *differential convergence education*, i.e., education carried through differential convergence projects or courses. As discussed in Section 5, such convergence can be feasibly afforded in the context of traditional disciplinary (discipline-based) education, along with or part of, but not instead of, disciplinary courses, though this may require and/or lead to some affordable changes in the curricula in place.

Since the very time the disciplinary schism took place in the history of academia, and especially as the schism grew up deeper, convergence has been taking place in one form or another to tackle specific issues and bring about certain products and services that could not come about by a single discipline alone. Convergence has even taken us at times against the tides of the schism and led to the emergence of new integrated disciplines from within the same field, like physical chemistry, biochemistry, and neurophysics in natural sciences, or from different fields like biomedical engineering that integrates knowledge from the three fields of natural sciences, health sciences, and engineering. Technology itself, with all technological product, from home appliances and computers to cars and airplanes, is a convergent field that sprung out primarily from science, engineering, and mathematics to fulfill social needs. All such convergence efforts have been differential. They have preserved the original disciplines from which their output emerged, and came about to the benefit of those disciplines.

Some university majors have also been set on similar differential convergence grounds, including majors in or related to education. This was the case with my own training in physics education about forty years ago in the physics department at ASU, and subsequently throughout my career as a university professor. My PhD involved differential convergence of disciplinary paradigms and practices primarily from physics, philosophy of science, cognitive sciences, psychology, and education. Throughout my career, other disciplines seeped in gradually in my work, especially neuroscience, and, to a lesser extent, sociology. All along though, convergence I went through was never formalized by any academic authority. As a graduate student, I took courses in the mentioned disciplines and I had to figure out on my own how to bring together respective knowledge for the benefit of my research, sometimes with the valuable help of my dissertation supervisors. This continues to be the case with university majors that take students through the hurdle of similar convergence tracks (Lyall, 2019).

There is no consensus in the literature as to what convergence is and should be about in education and elsewhere, not even regarding what a discipline is. Cooke et al. (2020), and Choi & Pak (2006) found a wide diversity of the definition of "discipline" in various dictionaries and related academic works in the literature. They also found a similar diversity regarding prefixes of disciplinarity commonly used with convergence like multi-, inter-, and trans-. In fact, scholars working on either form or modality of convergence, namely multidisciplinarity, interdisciplinarity, transdisciplinarity, and others, do not agree on such terms, and often use them interchangeably and even in conflicting ways (Choi & Pak, 2006; Cooke et al., 2020; Lenoir, Hasni, & Froelich, 2015; Stock & Burton, 2011).

These and other convergence types or modalities are being differently distinguished in the literature based on different classification criteria, and often different modalities are defined under the same label or the same modality is defined under different labels (*ibid*). Classification criteria focus primarily on theoretical and especially epistemological underpinnings and/or procedural and instrumental criteria. In the former respect, the focus is on the theoretical context in which convergence is achieved, convergence processes deployed from different disciplines, and the extent to which different disciplines and respective paradigms preserve their identities

or, alternatively, are integrated or transcended. Distinctions in the procedural respect are made in terms of how professionals from different disciplines come and work together, the scope of their work, and the nature of the outcomes brought about. In the following, we distinguish and discuss five modalities we hope will contribute to bringing some consensus around differential convergence especially for educational purposes.

2. Convergence modalities

Convergence, whether differential or not, involves professionals from different disciplines, academic and/or not, working together to bring specific issues to desired ends. An issue may be a question, a problem, a case study, the design and/or realization of a given product or service, a research or development project of any sort, etc. The end that a given issue is brought to depends on the theoretical and practical conditions under which concerned professionals work together on that issue. Different conditions may thus bring the same issue to different ends. In other words, different convergence lenses or different convergence modalities with the same disciplines and the same issue may lead to different outputs (Fig. 1).

We hereby attempt to bring some harmony into the diversity of modalities' classifications pertaining to academic and educational convergence research in the literature[4]. We do so by spelling out specific criteria around which we hope stakeholders to converge, especially those working in the educational sector with a vision to meet the realities of the 21st century in realistic and affordable ways. We then distinguish in terms of those criteria five differential convergence modalities of increasing cohesiveness and productivity: pluridisciplinarity, multidisciplinarity, interdisciplinarity, crossdisciplinarity, and transdisciplinarity.

The five modalities are outlined in this section with the recognition that there could be no one-size fits all classification, and that presented criteria and modalities are not universal and comprehensive in any aspect. In this entire work, we concentrate on what we believe are most significant aspects of differential convergence, especially from a pedagogical perspective that takes into considerations the realities of disciplinary curricula that still prevail and will continue to prevail for some time, at least in K-12 education.

Our five modalities are distinguished in terms of the following criteria that will hopefully become more obvious as we proceed with our outline of the modalities in question (Table 1):

1. The scope of work, and more specifically whether it is strictly confined to the issue of concern and its time frame, or it extends to other matters of everyday life and of theoretical and practical nature within the disciplines implicated in the convergence and beyond (Column 1 in Table 1).
2. The closeness of the implicated disciplines (actually disciplinary branches as noted above), and primarily whether or not they belong to the same realm[1] (Column 2).
3. How professionals from different disciplines come together and carry their collective work, and specifically whether they do so under cooperative or collaborative terms and in conservative, creative, or innovative ways (Column 3).

[4]See, for example, Baek, Cho, & Kim, 2019; Choi & Pak, 2006; Cooke et al., 2020; Crow & Dabars, 2015; Fuentes Canosa & Collado Ruano, 2019; Giri, 2013; Herr et al., 2019; Karbhari, 2018; Kötter & Balsiger, 1999; Lenoir, Hasni, & Froelich, 2015; Lyall, 2019; McGartland Rubio et al., 2010; NRC, 2014; Nicolescu, 2010; Stock & Burton, 2011.

4. The extent to which these professionals work across mutual disciplinary boundaries, bridge disciplinary divides, and come to mutual understandings on various foundational and practical respects in their collective work and beyond (Column 4).
5. The theoretical framework (or framework, for short hereafter) in the context of which convergence takes place, and particularly whether or not this framework entirely conforms to the paradigms[3] of the respective disciplines, and whether it brings together needed premises in cumulative or synthetical / integrative ways (Column 5).
6. The extent of conservation or, alternatively, regulation of conceptions and procedures[3] deployed from different disciplines, and whether or not new or novel conceptions and/or procedures emerge in the process (Columns 6 and 7).
7. The quality of convergence output, and particularly whether the issue of concern is brought to an end of familiar features or of original features that may reflect some creativity or innovation (Column 8).
8. The extent to which framework and convergence process and output can be extrapolated beyond the original scope of work, if any (Columns 9 and 10).

Convergence framework is perhaps the most important aspect, and unfortunately the least addressed explicitly in the literature. A framework consists primarily of foundational premises that bare directly to the issue of concern and that are drawn from the paradigms[3] of the implicated disciplines. These especially include epistemological and methodological premises that govern the choice and deployment of appropriate conceptions and procedures respectively. They also include axiological premises that make involved professionals respect fundamental ethics and moral values so that they would not cause any harm to concerned beings and the environment in their collective work.

Table 1

Major convergence modalities and their characteristics

Characteristics / **Modality**	Scope of work	Different realms disciplines	Collective work♣	Disciplinary bridges	Framework(s) and grounds in disciplinary paradigms	Epistemic changes in each discipline	Methodological changes in each discipline	Output originality	Extrapolation	Ultimately new discipline(s)
Pluridisciplinarity	Issue only	May be	Cnsrv ST Coop	No	Separate conformist frameworks	None	None	None	No	No
Multidisciplinarity	Discipline	May be	Cnsrv ST Coop	No	Separate conformist frameworks	Refined semantics	Refined rules	Insignificant	No	No
Interdisciplinarity	Open	Yes	Cnsrv ST Colb	Yes	Common hybrid framework	Refined semantics & syntax	Refined rules	Slightly	Yes	No
Crossdisciplinarity	Open*	Yes*	Crtv LT Colb	Yes	Common emergent framework	New conceptions	New procedures	Significant/ Crtv	Yes*	No
Transdisciplinarity	Open*	Yes*	Invtv LT Colb	Yes	Common transcendent framework	Novel conceptions	Novel procedures	Significant/ Invtv	Yes*	Yes

* Long-term projects related to everyday life and involving non-academic fields that, traditionally, are not the object of general education.

♣ Cnsrv = Conservative; Crtv = Creative; Invtv = Innovative or inventive; ST = Short Term; LT = Long Term; Coop = Cooperative; Colb = Collaborative.

Box 1. Glossary of terms as intended in this work**.**

Collective work

Cooperation: Individual, or groups of, professionals working in parallel or in series, sequentially without reiteration like in an assembly line, to tackle an issue (question, problem, case study, product design or manufacture, research or development project, etc.) that is often of particular interest to one specific participant (individual or group). Tasks are distributed and each participant carries out the respective task separately and independently of other participants. Participants' contributions are compiled at the end of the joint venture as individually produced, without raising throughout the venture any question about any contribution or any implicated discipline.

Collaboration: Participants (individuals or groups) work jointly together as a team of co-owners of shared responsibility on an issue of mutual interest. They coordinate and share tasks and revisit their work throughout the joint venture for evaluation and regulation under specific terms mutually agreed upon. The final output may result of progressively integrating individual contributions.

Work process and output

Conservative: Conforming to existing and mutually accepted premises (tenets, principles, and other foundational propositions), rules, norms, and standards, and looking like, or reminiscent of, already known or established processes and entities (objects, ideas,... and their properties) hereafter referred to cumulatively or separately as "things", whether concrete or abstract.

Creative: Derived or extrapolated from existing things, critically and insightfully, and deployed in new ways and with new specifications or attributes, but in accordance with existing and mutually accepted premises, norms, and standards.

Innovative: Brought about critically and insightfully in novel ways and with novel specifications or attributes, in accordance with new premises, norms, and standards.

Framework

Conformist: Drawn from one (or more) specific paradigm(s) while entirely preserving and strictly adhering to all concerned paradigmatic premises.

Hybrid: Resulting from bringing harmoniously together premises from different paradigms, without synthesis or integration, and in total conformity to such paradigms.

Emergent: Resulting from the synthesis or integration of premises from different paradigms, in conformity to such paradigms, and resulting in especially new epistemic and methodological aspects that cannot be attributed to any of the combined premises taken alone.

Transcendent: Resulting from transgressing existing paradigms in certain respects, and bringing about novel and unprecedented paradigmatic premises that are meant, in differential convergence, more to complement than to supervene the paradigms in question.

Episteme

Conception: A concept or a relationship among concepts (including axioms, laws, theorems, etc.).

Semantics: Meaning of a conception in the epistemic context of a given discipline, and aspects it refers to or corresponds to in a set of things in the real world or abstract realm of the discipline.

Syntax: Rules for setting relationships or connections and carrying allowed operations (e.g., derivation or transformation) within and among conceptions.

Methodology

Procedure: A process, mechanism, or operation, along with necessary tools, resources, and other means for carrying it out in defined settings and in accordance with well-defined rules and guidelines, including norms and standards for choosing appropriate means.

Specific attributes (especially of conceptions and procedures)

Refined: Improved following evaluation and regulation that brings it out with familiar specifications, and in conformity with established norms and standards.

New: Not known before in a specific context, but can be traced in certain respects to already known premises or things.

Novel: Not known before and cannot be traced in any significant respect to already known premises or things.

The framework governs a convergence modality in its entirety, from defining the issue to be tackled, to setting the theoretical and practical terms and conditions of collective work and subsequently selecting and deploying the appropriate conceptions and procedures, all the way to bringing the issue at hand to its desired end. In education, the framework has in addition to paradigmatic premises of academic disciplines a pedagogical component that includes primarily cognitive premises pertaining to learning and instruction.

Table 1 summarizes how the five convergence modalities are distinguished in terms of the eight criteria mentioned above. Certain words used in this table and throughout our discussion have special meanings for us as expressed in Box 1. The modalities are outlined next. The outline indicates how each modality differs from its predecessors relative to those criteria and what added features it brings about. A particular example with simple features about testing the efficacy of a medical drug designed for production in different formulas is used for illustration. The conditions of drug testing and production are progressively modified to meet the terms of each convergence modality. Our discussion in this section is followed in the next section with a summary of key aspects that cut across all modalities. Both sections pertain to research and development in general. Extrapolation to education makes the object of the last section.

2.1 Pluridisciplinarity

Pluridisciplinarity is the simplest and most conservative convergence modality. It is about output-focused distributed or separate tasks whereby professionals from different disciplines, often in the same field and/or the same realm, come together for a one-time, short-term *cooperation* on a particular issue (question, problem, case study, product design or manufacture, research or development project, etc.).

The issue that may or may not relate to everyday life may be of exclusive interest or concern to one particular party (individual or group of professionals) coming from one particular discipline, or it may interest one party far more than others. This party seeks the cooperation of professionals from other disciplines the disciplinary knowledge and expertise of whom is indispensable for handling the issue at hand. Cooperation is sought often not to help specifying the output, which this party reserves to itself, but to facilitate the process of getting it.

Pluridisciplinary cooperation may take place on an informal basis with various parties working, to a large extent, separately and independently of each other. In contrast, it may be somewhat structured with the concerned party taking the lead in defining the issue of interest and laying out the terms of cooperation. These terms are usually limited to the following:

1. Defining the scope of work restricted to issue resolution.
2. Setting criteria for the sought output (how to determine if the issue is satisfactorily resolved).
3. Delineating the expected contribution (and reward or compensation, if any) of each participant (individual or group of professionals from a given discipline).
4. Setting the cooperation agenda, in consultation with participants, in the form of a limited number of stages (or perhaps only one stage) of particular timetable and task to be achieved by each participant by the end of each stage, leaving it to each participant to decide on all the logistics to get there.

Throughout their short-term, limited cooperation, participants concentrate only on the issue of interest in its spatial (social included) and temporal confinements, and pay no attention to

possible implications of their work, be it beneficial or not, beyond the handled issue. They work separately in the confinement of their individual disciplines, totally independently of each other's discipline and of other disciplines in all foundational and practical respects. They proceed in parallel and sequence without reiteration, i.e., from one task to the next without any participant checking with other participants and without going back to a previous stage for any regulation or change. Their cooperation then truly converges only at the end with the output, and not at any point during the process of bringing about this output.

Each participant (individual or group) adapts a *separate framework* that draws exclusively on the paradigm of the respective discipline, and relies exclusively on the episteme and methodology of this particular discipline[3] (or specific disciplinary branch[1]). Participants proceed in *conservative* ways that preserve the integrity of each discipline in all respects. They conform to their disciplinary paradigms as they stand in all their premises, irrespective of any

Box 2. Some major aspects of a pluridisciplinary research conducted to ascertain the efficacy on a certain illness of two drugs produced with the same ingredients but in different proportions.

1. The drug company defines the issue it wants to address (production of a drug following specific formula(s)) in a pluridisciplinary perspective and sets the terms of cooperation with concerned parties. The scope of collective work is limited to the comparative evaluation of the efficacy of the two drug formulas in healing or improving, in specific respects, the condition of a sample of concerned patients during a fixed period.
2. The company negotiates with clinics (physicians), medical laboratories, and, perhaps, outside statisticians to decide on whom to cooperate with.
3. Participants (company, clinics, medical laboratories, statisticians) set their individual frameworks that draw on their individual paradigms to carry out accordingly their respective tasks.
4. The company produces the drug in two formulas, one following the exact composition already available in the market, the other with the same ingredients but in different proportions. A placebo may also be considered.
5. The company sets out to test two null hypotheses. The first hypothesis supposes that the drug this company produces with the exact same formula available in the market brings about the same results already known for that drug (and better than the placebo, if any). The second hypothesis assumes that the drug with the new proportion of ingredients leads to better results in specific respects. The company sets in consultation with clinics and laboratories treatment results needed to make proper judgment about each hypothesis.
6. Clinics set patient variables to collect data about in order to ascertain the efficacy of the two formulas, along with the appropriate protocols for patient treatment and follow up. Protocols include medical tests to be run by commissioned laboratories in accordance with established premises and protocols.
7. Statisticians (within or outside the company) decide how to document and analyze collected data, including appropriate statistical tests and coefficients that determine whether to accept or reject either hypothesis.
8. Clinics choose the sample of patients that they need to test the formulas on in accordance with established regulations and ethical and moral codes. Treatment subsequently begins following the designated protocols, and clinics and laboratories collect data without any change in protocols and without the intervention of other parties. Once all data are in, they are reported to the company and/or statisticians.
9. Once they receive all needed data, statisticians proceed to data analysis in ways to help the company come to proper judgment regarding the hypotheses, and subsequently to an appropriate decision regarding the production of the drug with the same ingredients and the same and/or different proportions.
10. Throughout the entire research, neither party questions the value of drug ingredients or any of the conceptual and procedural knowledge relied upon in any discipline, whether in health sciences or statistics. Each party carries out its task in the sequence shown above and completes it without reiteration in accordance with the terms of cooperation agreed upon at the beginning of the cooperative venture.
11. Cooperation ends with the appropriate decision regarding the hypotheses and drug production with no significant implications to any party beyond that point.
12. Though directly concerned along with their patients, participating physicians, like any other participant outside the drug company, do not intervene in drug specifications and production throughout the pluridisciplinary enterprise and beyond. At any point, and once the drug is produced by the investing company, concerned physicians may only decide whether or not to prescribe the drug to their patients.

challenge that may arise to any such premise. The same goes at the epistemic and methodological fronts where conceptions and procedures are simply adducted and reproduced as needed without being questioned or regulated in any implicated discipline should any drawback, discrepancy among disciplines, or any other challenge emerge.

The resulting output, whether an object or a process, is cumulative or discretely additive and totally reproductive. Like a patchwork or a quilt, it comes about from a mere compilation not a synthesis of what has been adducted or elicited from different disciplines, and can be entirely traced back to what is already known in and about the implicated disciplines with no originality or novelty in any of its parts.

Pluridisciplinarity is perhaps the most popular convergence modality, especially when cooperation takes place on informal basis among academics or when one party has far more at stake with the handled issue than others. This is for example the case when a pharmaceutical company wants to carry out a field research to decide whether to produce a given drug already in the market with the exact formula applied by other companies, or with a different proportion of the same ingredients already used in the production of the drug. The company may then cooperate with a number of parties including but not limited to physicians to test the two drug formulas on concerned patients, and medical laboratories to carry out specific tests on patients and ascertain the effect of prescribed drugs on specific health factors. The company may also cooperate with outside statisticians to handle some aspects of data analysis. Box 2 presents an outline of some major tasks handled by different parties in a pluridisciplinary perspective up to the point of deciding in what formula(s) the company will produce the drug. Note that aspects outlined in Box 2 would apply similarly if the issue were about comparing the efficacy of two instructional methods with a given population of students through pluridisciplinary research.

All in all, pluridisciplinary endeavors are short-term conservative, cooperative endeavors strictly confined to a particular issue. They conform entirely to existing paradigms, episteme and methodology included, and are totally reproductive in their approach and output. They result in no change in implicated disciplines. Disciplinary paradigms are entirely preserved, and so are the entire disciplinary repertoires of conceptions and procedures in all their semantic, syntactic and regulatory details.

2.2 Multidisciplinarity

Multidisciplinarity is a conservative, cooperative convergence modality that shares many features with pluridisciplinarity. However, it has some advantages over the latter modality because of the following differences (Table 1):

1. The issue is now of mutual interest to all participants and not of exclusive or prime interest to one particular participant (individual or group of professionals).
2. Participants, though primarily confined to the issue at hand, pay some attention to possible implications of their work on some epistemic and methodological aspects of their individual disciplines, but only in the direction of making affordable refinements.
3. Participants may contrast and evaluate their disciplinary conceptions and procedures and lay the finger on some discrepancies or other issues within and among disciplines.
4. The output is still cumulative and predominantly reminiscent of existing disciplinary byproducts, yet it may present minor and insignificant originality.

Like in the case of pluridisciplinarity, participants continue here to conform entirely to the paradigms of their individual disciplines, from paradigmatic premises to episteme and methodology. However, and unlike before, they begin now to look across the boundaries of their disciplines, yet without transgressing boundaries or conceiving ways to bridge their disciplinary divides. Their efforts in this respect are limited to refinement and improved efficiency with no significant change in any respect. They mostly try to infuse some harmony into the diversity of the semantics of their common or related conceptions and of the rules of their common or related procedures, all in conformity to the epistemic and methodological premises of their individual disciplines. Significant inconsistency and incongruence, if detected, are only bypassed, not regulated, in order to still preserve the fundamental integrity of their disciplines. Participants in pluridisciplinary and multidisciplinary cooperative ventures alike are usually not inclined to share their experience with their professional communities.

Multidisciplinarity is a popular convergence modality, and perhaps the most popular when cooperation needs to be formalized among academics, and when these are open, in conformity to existing paradigms, to come to common understandings on their related conceptions and procedures without inducing significant changes in any conception or procedure. This would be for example the case of our previous example when all involved parties deliberately reflect back on what they bring to the table from their epistemic and methodological repertoire as they proceed through their cooperative venture without change in task distribution, ownership, and execution. All items then stand as they appear in Box 2 except possibly for items 10 and 11. Unlike pluridisciplinarity, multidisciplinarity allows for semantic and minor routine operational refinements (Table 1) in Item 10, and for perhaps some change in secondary but not primary drug ingredients in Item 11 (e.g., adding ingredients that help speed up or slow down the digestion and activation of the primary ingredients that are the object of research).

All in all, multidisciplinary endeavors, like pluridisciplinary ones, are short-term conservative, cooperative endeavors concerned with a particular issue within the confinement of implicated disciplines. Participants adhere strictly to their paradigms, and are largely conformist in their approach and output. Except for limited refinement in some semantic and regulatory aspects, they result in no significant change in the concerned disciplines.

2.3 Interdisciplinarity

Interdisciplinarity is another conservative convergence modality that preserves the integrity of implicated disciplines, entirely in a foundational paradigmatic perspective, and to a large extent in epistemic and methodological perspectives. However, it has many advantages over pluridisciplinarity and multidisciplinarity mostly in the following respects (Table 1):

1. Participants from necessarily different realms come together for often short-term *collaboration*, instead of cooperation, on one particular issue of mutual interest that necessarily relates to everyday life and, unlike the previous two modalities, to traditionally non-academic fields.
2. Collaboration is somewhat equitable in the sense that participants from various disciplines are actively and interactively engaged throughout the collaborative work on equal footings. They are no longer called upon, as with pluridisciplinarity and multidisciplinarity, to serve the agenda of a primary stakeholder without having a say in determining the nature of the output and the actual process of getting it.

3. Participants now work together all along and not separately and independently of each other as before, and do so not under separate disciplinary frameworks but under one common *hybrid framework* that draws cumulatively, with no synthesis or integration, upon all their paradigms.
4. Participants are mostly focused on, but not rigidly confined to, the issue at hand. They now look for possible implications of their work on life matters in addition to their disciplines. They do so in the latter respect jointly in each other's discipline and not separately in their individual disciplines as before, and this by bringing together

Box 3. Measures that help converting the research of Box 2 on drug efficacy from pluridisciplinary cooperation to interdisciplinary collaboration.

1. The drug company calls upon concerned parties to discuss and define the envisaged issue (production of a drug following the same two formulas as before) and set together the terms of collaboration on this issue in an interdisciplinary perspective. The scope of collective work is extended, beyond the efficacy of the two formulas on the physical health conditions they are meant to treat, to a comparative assessment of the formulas' long-term impact on certain psychological and social aspects of treated patients.
2. Participants now include psychologists and sociologists in addition to the drug company, physicians, medical laboratories, and outside statisticians, all engaged on equal footings.
3. Participants come all together to set one common hybrid framework for their collaborative venture. The framework brings cumulatively together, without synthesis or integration, needed premises from the disciplinary paradigms of various participants.
4. The company produces the drug in the same two formulas as before, along with a placebo.
5. Participants set together the null hypotheses and everything needed to make proper judgment about each hypothesis. The hypotheses may be expressed in similar ways to those of Box 2 while accounting for the designated psychological and social aspects, as well as for the placebo.
6. Participants all agree on patient variables to collect data about in order to ascertain the efficacy and side effects (physical, psychological, and social) of the two formulas, and set the appropriate protocols for patient treatment, monitoring, and follow up.
7. Participants all agree on how to collect, document, and analyze data, including appropriate statistical tests and coefficients that determine whether: (a) there is any need to regulate the adopted protocols at specific points of implementation, and (b) to accept or reject each hypothesis at the end.
8. Physicians choose the sample of patients that they need to try the formulas on in accordance with established regulations and ethical and moral codes. Treatment subsequently begins following the designated protocols, and data are collected and continuously analyzed and shared among all participants. Protocols are revisited at designated implementation points to determine, with all participants' agreement, if changes are necessary and can be feasibly implemented along the road.
9. Once patients' treatment is completed and all needed data collected, statisticians proceed to data analysis in consultation with all parties in order to come to proper judgment regarding the hypotheses, and subsequently to an appropriate decision regarding the production of the drug with the same ingredients and the same and/or different proportions.
10. Throughout the entire research, neither party questions their disciplinary paradigms or the ontology of any of the deployed conceptions and procedures. However, the considered protocols may be revisited and regulated as mentioned above in the context of the adopted hybrid framework, and the semantics and syntax of certain conceptions and rules of certain procedures may be refined in accordance with, and preservation of, paradigmatic premises of various disciplines, epistemic and methodological included.
11. Cooperation does not necessarily end with the appropriate drug production that may take place with a change in either originally tested formula. Lessons learned in all respects throughout the collaborative venture are extrapolated within the areas of interest of each participant in ways to benefit their respective fields and disciplines.
12. Participating physicians and all other parties may consider to extend their collaborative venture in a longitudinal research after drug production to keep track of treated patients and continuously evaluate the drug in all physical, psychological, and social respects addressed above and perhaps more. Drug production may then be eventually reconsidered based on data collected in the longitudinal research.

conceptions and procedures from their individual disciplines in cumulative ways without synthesis or integration.

5. Transfer from one discipline to another and intrinsic regulation now begin to take place in epistemic and methodological respects but only in the direction of making affordable refinements in conformity with disciplinary premises in these respects.
6. The output is still cumulative and largely reminiscent of existing disciplinary byproducts, yet, and unlike before, it may present some significant originality and it may be extrapolated beyond the original scope of work, thus opening the door for a long-term collaboration.

Participants continue to conform here, like in the case of the former two convergence modalities, to their disciplinary paradigms. However, and unlike before, they now begin to wander across the boundaries of their disciplines, and, though still hazily, transgress boundaries and conceive some primitive bridges across disciplinary divides. They may subsequently contrast each other's conceptions and procedures and enhance or refine the semantics and syntax of existing conceptions, optimize rules and guidelines of established procedures, and come to mutual understandings on such matters. However, they continue to bypass without resolution mutual discrepancies or challenges that necessitate significant conceptual or procedural changes. Finally, and like with crossdisciplinarity and transdisciplinarity, participants now share their collaborative experience with their professional communities.

The drug production example of Box 2 would turn into an interdisciplinarity venture when converted in the manner indicated in Box 3. The reader is invited to contrast corresponding items in the two boxes to realize the advantages that interdisciplinarity brings over the previous two cooperative modalities as summarized in Table 1.

Interdisciplinarity is perhaps the most affordable modality for beginning to infuse meaningful convergence into traditional disciplinary settings, primarily because it still conforms to disciplinary paradigms and preserves the integrity of implicated disciplines in various respects. Through conservative collaboration, this modality allows for transfer across unfettered disciplinary boundaries for mainly bringing about shared meanings and understandings on existing conceptions and procedures without significant ontological change to any conception or procedure, and without necessitating the inception of new conceptions or procedures. Significant changes still await the following two convergence modalities.

2.4 Crossdisciplinarity

With crossdisciplinarity, convergence begins to have its full significance through creative collaboration that goes beyond infusing relative harmony into existing disciplinary conceptions and procedures in conservative ways that totally conform to the ontology of various disciplines as before. Crossdisciplinary convergence synthesizes or blends various disciplinary elements in somewhat integrative ways that allow for the emergence of new paradigmatic aspects, foundational, epistemic, and methodological, in any implicated discipline. More specifically, this modality proceeds in new and more productive ways that include the following:

1. Participants from necessarily different realms, including traditionally non-academic fields, come together for a long-term and equitable, *creative* and *not conservative* collaboration that is life related, no longer confined to any particular issue, and not necessarily limited to one particular project.

2. Participants work together all along under one common *emergent framework* that draws upon, and conforms to, all their paradigms with synthesis or relative integration, and thus that implies some additions to, and/or changes in, the paradigmatic premises of their individual disciplines.
3. Participants rely mutually on their disciplines in *creative* ways that involve reiterative, critical evaluation and insightful regulation of various disciplinary premises and components, and that lead to any or all of the following:
    a. Deployment of existing conceptions and procedures in unprecedented ways.
    b. Regulation of conceptions and procedures in ways that may change any of them significantly, and not only infuse harmony in conceptual semantics and syntax or induce conservative procedural refinements.
    c. Inception of *new* conceptions and/or procedures by derivation from, or extrapolation of, existing epistemic or methodological components.
4. The output is creative and no longer cumulative and reminiscent of existing disciplinary byproducts. It comes about with significant originality in many or all respects, and is prone to extrapolation in ways to widen the scope of implicated disciplines in both domain and function.
5. Unlike the previous three modalities, crossdisciplinary convergence is truly *systemic* and somewhat *integrative*. With the former modalities, participants focus on specific conceptual and/or procedural components of their individual disciplines, and only in relation to a given task and not the big disciplinary picture. With this new modality, the focus becomes on each discipline in its entirety, its wholeness, and in relation to other disciplines. A truly systemic perspective in the sense discussed in Section 4 begins to take shape here in a critical and insightful way so that creative disciplinary changes may subsequently be brought about. Those changes often result from synthesis and integration of disciplinary components in the manner discussed in point 3 above.

Crossdisciplinarity is a cross-breeding, cross-fertilizing, or cross-pollinating convergence modality (whence the cross- prefix in the name of this modality) that requires continuous crossing of boundaries among disciplines, mutual and reiterative critical evaluation and insightful regulation of various disciplinary aspects, and bridging of disciplinary divides. It leaves it subsequently to participants' creativity to bring about significant changes in all paradigmatic and practical respects. Those changes are emergent in the sense that they stem from existing premises and epistemic and methodological components and come out with new aspects that cannot be attributed to anything they emerge from but that can always relate and conform to implicated disciplines.

The drug production example considered so far would turn into a crossdisciplinary venture as outlined in this section and in Table 1 when, preserving other items (and replacing inter- with cross- disciplinarity), some items in Box 3 are changed as follows:

- A new drug with partially or entirely different ingredients is considered in Item 1 and throughout the collaborative venture, in addition to, or even instead of, the drugs with established ingredients.
- An emergent framework replaces the hybrid framework of Item 3, and everything takes place accordingly in subsequent items.
- Everything in Item 10 may now be questioned and subject to significant regulation without transgressing any discipline.

- Extrapolation is open to all disciplines and fields in Item 11, including the production of all sorts of drugs.
- Disciplinary premises and components may be reconsidered in Item 12, as well, with possibly continuous emergence in any disciplinary respect.

Crossdisciplinarity is the optimal convergence modality that may be carried out in traditional disciplinary settings at a reasonable cost. The modality is quite differential and does not call for, or result into, a paradigmatic shift or revolutionary disciplinary changes, which may help taming down opposition from conservative voices anywhere they might be. Changes it brings about are yet systemic and significant as they may affect various paradigmatic aspects of any given discipline. Through creative collaboration, this modality removes all paradigmatic and practical barriers among disciplines, bridges disciplinary divides, and brings about original, systemic disciplinary and practical daily life outcomes that could not be brought about under any of the previous three conservative modalities.

2.5 Transdisciplinarity

Transdisciplinarity is the ultimate convergence modality that surpasses by far all other modalities. Like crossdisciplinarity, it is a non-conservative, long-term collaboration that brings about original outcomes in disciplinary and daily life respects. However, it goes a leap ahead the former modality by not simply linking existing disciplines in different realms, but by going outside and beyond disciplinary boundaries altogether to transcend without giving away existing disciplines. As such, transdisciplinary differs from crossdisciplinarity and other modalities in the following respects:

1. Participants work together all along under one common *transcendent* framework that integrates premises from the paradigms of implicated disciplines and adds new premises that transcend those paradigms.
2. Participants rely mutually on their disciplines in *innovative* ways that involve reiterative, critical evaluation and insightful regulation of various disciplinary premises and components, leading to completely *novel* premises and components that do not necessarily relate to existing ones and that bring about a novel output that is completely original in most if not all respects.
3. The entire experience is continuously *extrapolated in all systemic perspectives* to bring about innovative byproducts leading possibly to the creation of an entirely *new discipline* that may cut across existing fields and realms or lay the ground for a completely new field.

Transdisciplinarity is a convergence modality that transcends existing disciplines (whence the trans- prefix in its name) in all foundational and practical respects in order to bring about novel and unprecedented outcomes that could not be conceived or even foreseen in the confinements of existing disciplines, whether separated or integrated. When all other modalities, and especially crossdisciplinarity, fail to meet the ends set for collective work, transdisciplinarity becomes the only resort. This is especially the case when faced with unprecedented issues with no known ways out, like a totally new disease that has not been confronted before in any form and for which no treatment is available or may be conceived in the confinements of existing paradigms and knowledge in health sciences. An entirely new drug would then have to be produced, very likely in a transdisciplinary venture as outlined here and in Table 1. Such venture would follow suit with Box 3 modified as discussed with

crossdisciplinarity, but with transcendence taking over emergence and opening the door for innovation in all respects (including drug ingredients).

Transdisciplinarity is the ultimate convergence modality that requires significant compromises in traditional disciplinary settings. Though differential and leaving enough room for traditional disciplines to coexist on distinct territories, it does not totally preserve the integrity of such disciplines, and it leads to conceiving new knowledge outside their confinements. This may, and already did, raise numerous eyebrows and confrontation with significant opposition from conservative academics and other professionals on all fronts. However, transdisciplinarity is yet the most productive and innovative convergence modality that opens the door to seeing the world with new paradigmatic lenses without denying the merits of existing disciplines. As such, it allows tackling any issue in innovative and not just creative or conventional ways, and raising new issues that cannot be handled or even conceived with other modalities, and especially not with traditional segregated disciplines.

The digital revolution of our era, the breakthroughs in neuroscience, especially cognitive neuroscience, which education may benefit of most, and the many new careers that keep popping up in the job market and that could not have been foreseen or even imagined just a decade ago, are all compelling testimonies in favor of crossdisciplinarity and, especially, transdisciplinarity. Many universities and enterprises in the job market are already there or heading this way. Others, especially in education, have no choice but to shoot for transdisciplinarity, or at least crossdisciplinarity, and work urgently to get there progressively, beginning with the modality that suits them best.

3. Key aspects of differential convergence

The five modalities of differential convergence are primarily distinguished as shown in Table 1 and discussed above. Certain key features that we came across in our discussion are worth taking up further here, along with particular implications and challenges, in order to keep things in perspective, especially for educational applications discussed in the last section.

3.1 Flexible deployment under well-defined frameworks

Classification criteria and convergence modalities are neither exclusive nor exhaustive. They are not meant to be taken for granted and rigidly adopted in any situation. They should rather be flexibly adapted to existing conditions. We have tried to concentrate on features that could contribute to bringing about some consensus in convergence practices, or at least some harmony into the diversity of classifications in the literature, especially for educational purposes. In the meantime, we have tried to avoid debatable philosophical and esoteric issues that would distract the reader from the main message we are trying to get across.

As much as we acknowledge the necessity to consider criteria and modalities flexibly, we do hold that one criterion stands out as most critical for success and should be given due attention in any context. This is the framework; the conceptual lens through which convergence takes place (Fig. 1) in order to proceed efficiently and come to worthy ends. Like in any research and development venture, whether academic, educational, or else, without a well-defined framework, people converging on any issue would follow rules of thumb that can hardly bring them to a consensus on any aspect of their collective work. They would subsequently come to no rewarding ends, or at best achieve their work not as efficiently and successfully as they would have hoped.

3.2 Gradual value-added convergence

Differential convergence is most significant with cross- and trans-disciplinarity. Crossdisciplinarity is the ultimate affordable modality one can aim for in conventional disciplinary (discipline-based) settings, within and outside the educational sector, whereas transdisciplinarity is the most productive and innovative modality that requires venturing beyond disciplinary boundaries. Our convergence modalities are gradually scaled up so that people can progressively move toward the ultimate modality of their choice beginning with the one they can afford most. Convergence gets more and more cohesive and productive, and more and more people and communities get to benefit from it, as we move from pluridisciplinarity to transdisciplinarity (Table 1). In particular, progress takes place gradually from the former to the latter modality in the following respects (cf. Box 1 for the intended meanings of some terms):

- Collective work first takes place cooperatively (pluri- and multi-disciplinarity), and then collaboratively (inter-, cross-, and trans-disciplinarity), and is at first focused uniquely on the issue at hand (pluridisciplinarity) and individual disciplines drawn then only from the same academic field or realm (multidisciplinarity). Collaborators begin afterwards envisaging related everyday life issues (interdisciplinarity), and implicating, on a long-term basis rather than a short-term basis as before, disciplines and professional communities from different realms and traditionally non-academic fields (cross- and trans-disciplinarity).
- Disciplines are first implicated separately and independently of each other during cooperative work (pluri- and multi-disciplinarity), before collaborators begin to bridge disciplinary divides, at first hazily (interdisciplinarity), and then solidly (cross- and trans-disciplinarity).
- Convergence framework evolves from conforming rigidly and in conservative ways to separate disciplinary paradigms (pluri-, multi-, and inter-disciplinarity), to involving paradigmatic synthesis and bringing along emergent premises (crossdisciplinarity), and then transcendence of certain original disciplinary foundations (transdisciplinarity).
- Convergence processes are at first reproductive and result in no significant added value to implicated disciplines (pluri-, multi-, and inter-disciplinarity); they become afterwards productive and creative (crossdisciplinarity) and then innovative (transdisciplinarity) at the level of both implicated disciplines and the output they bring about.
- Conceptions and procedures are first deployed as they originally stand in their individual disciplines with no evaluation and no regulation in any respect (pluridisciplinarity), before conceptions become subject to refinement in semantic respects (multidisciplinarity) and then in syntactical respects as well along with procedural rules (interdisciplinarity); new conceptions and procedures begin emerging afterwards (crossdisciplinary) followed by novel ones (transdisciplinarity).
- Cooperative work ends once the issue at hand is satisfactorily resolved (pluri- and multi-disciplinarity), whereas subsequently collaborative work is extrapolated to related issues within the confinements of implicated disciplines (interdisciplinarity), and then to other issues outside the realm of the implicated disciplines (cross- and trans-disciplinarity). Extrapolation may go to the extent of the emergence of a new discipline (transdisciplinarity).

3.3 Realistic convergence

Differential convergence is not about a "theory of everything" and does not come to the detriment of any discipline, even in the case of transdisciplinarity. It is not about integrating or bringing together in any other form entire disciplines, not even entire branches in given disciplines, and absolutely not about integrated curricula in education. It is about bringing together some but not all knowledge from different disciplinary branches; a limited number of paradigmatic premises, conceptions and procedures (hereafter referred to individually or collectively as disciplinary elements) for tackling specific issues. Any issue tackled through any convergence modality requires only some elements from any discipline, and these elements can be chosen so as to be feasibly brought together and processed by concerned professionals. In fact, no issue may be tackled if it is beyond the potentials of these people. This is especially true for differential convergence education as discussed in Section 5.

At all times, including when synthesis or integration take place (cross- and trans-disciplinarity), differential convergence is always partial and carried in ways that respect the sovereignty of individual disciplines and that come to their benefit. When integration takes place, it does not necessarily require fusion, radical changes, or supervenience of deployed disciplinary elements. Supervenience does not even take place in the case of transdisciplinarity. Transcendence is then meant more to complement than to supervene or even supersede existing disciplines. It is meant to help tackling issues those disciplines are not equipped for and thus often falling outside their scope. In this sense, emergence (crossdisciplinarity) and transcendence (transdisciplinarity) in differential convergence are more evolutionary than revolutionary. They help finding new and better solutions to old problems, solving problems that could not be solved before, and especially, asking new questions that could not even be conceived before and that may be crucial to the advance of humanity and the ecosystem at large.

Sometimes the convergence is rather *translational* and not integrational. In translational ventures, elements of a particular discipline are deployed in another discipline in ways to induce changes into the latter but not the former discipline. This is for example the case when drug manufacturers take advantage of clinical research, biology, and chemistry, among others to produce their drugs. This is also the case when we adduct some principles or corroborated facts from cognitive science or neuroscience into education. In the latter case, the educational community, like a drug manufacturer, tries to accommodate itself to the adducted disciplinary elements and subsequently regulate or change things only in education, if necessary, to the extent of emergence or even transcendence, without necessarily implying any change in the adducted elements.

3.4 Stakeholders' engagement

Convergence is needed primarily to tackle issues that relate directly or indirectly to human and ecological welfare. Concerned groups in a given community, local or global, need then to be represented and actively engaged in tackling such issues in addition to academic and other professionals that may originally be behind the call for collective work. The better all stakeholders take part in convergence efforts, the better the output would serve the actual needs of directly implicated people, although this may somewhat complicate the work logistics. This is true in any sector, including the educational sector. Students can be motivated enough to carry out convergence projects meaningfully and productively only if these projects relate to their everyday life, and if they get to interact in the process with concerned people in their community.

3.5 Cultural implications

Convergence brings together people from different academic and possibly other professional communities, and induces them, especially in cross- and trans-disciplinarity, to negotiate their disciplinary knowledge and come to some consensus on, or with, such knowledge in order to come out with creative and innovative ideas. Such negotiations sometimes imply significant changes in disciplinary knowledge, and subsequently in the traditions or culture of each community. Changes may extend from conceptual semantics and subsequent discourse and communication, to procedural premises and subsequent collaboration practices, and then to overarching foundational premises and subsequent beliefs commonly held and dearly cherished. All along any collective work, ethical and moral values may also be boosted up as people strive to work together constructively and with mutual trust and respect, and ensure that convergence processes and output come about with no human or ecological harm.

As a consequence of all the above, a common and critical consciousness ought to be developed across different professional communities, toward issues of common interest as well as toward their own disciplines, so that they would continuously reflect on their paradigmatic premises and practices, insightfully regulate them, and enhance their readiness to tackle any new issue. In the event of any conflict between disciplinary cultures or agendas and the welfare of mankind, society, and the ecosystem at large, regulation should be done in favor of the latter and not the disciplines or disciplinary community (or concerned corporations). This where axiological premises of the convergence framework come to work and push the common consciousness of professionals from different disciplines in the favored direction.

3.6 Challenges

Convergence is supposed to work to the advantage of all concerned people, communities, and ecosystems. It is also supposed to boost constructive communication and collective work among stakeholders, and lead to continuous development of knowledge and learning and work habits within, across, and beyond disciplinary boundaries. However, like any collective work that brings together people from different backgrounds who might have already developed certain inertia or tradition of doing things within their own territories, convergence does not come about easily. It faces and raises many challenges that might work to its own detriment unless heeded prudently and met with upper hand.

Convergence, in any modality, requires people to come together from different disciplinary backgrounds, and thus with different languages of communication (different conceptions or conceptions of different semantics) and different work habits. This might cause misunderstandings and perhaps some friction that can be avoided only with the adoption of mutually agreed upon frameworks, conceptual and procedural repertoires, and especially general terms of reference for the collective work. These terms should be consciously and purposely set to promote common and equitable ownership of the collective work with mutual respect and trust, and avoid any sort of discipline or culture related supremacy, or any tilt in the balance of power in favor of some but not others, especially when profit is at stake.

Crossdisciplinarity and transdisciplinarity are particularly needed when it comes to creative and innovative practices in the job market and various other aspects of life, and to new careers that keep surging with unprecedented qualification requirements, which keeping up with, especially in education, is a challenge by itself. These two modalities impose a significant shift from traditional disciplinary practices and educational systems, and thus require stakeholders to have enough gist and willpower to break away from their inertia and traditions, give up ideas

and practices that they hold dearly and firmly, and transgress their disciplinary barriers and boundaries. This may not be easy – or even realistic – if stakeholders are not sufficiently trained and ready to take up such venture, and if the proper work environment along with sufficient incentives and efficient support systems are not in place to motivate these people and sustain their work and enthusiasm in this direction.

All in all, convergence must turn into a common mindset, a culture that can be welcomed and afforded especially by people that are entrenched in their disciplinary traditions. Those people are reluctant and sometimes strongly opposed to move out of their comfort zones, cross untouchable boundaries, and venture in new territories in ways that require extra effort and hard work. Committed, visionary, insightful, caring, and daring leaders are needed to rally these and other people around worthy convergence efforts, with a morally guided entrepreneurial spirit within well-established, suited, friendly, and motivating environments.

4. Systemic convergence

Any convergence modality should be carried out with an appropriate convergence lens (Fig. 1), i.e., in the context of, or under an appropriate framework. Given the diversity of disciplines and the paradigmatic divides that separate them, especially when coming from different fields and different realms[1], it often takes a hard effort to put together any convergence framework. The task may become significantly easier if different paradigms had some foundational premises in common. This is what systemism can do.

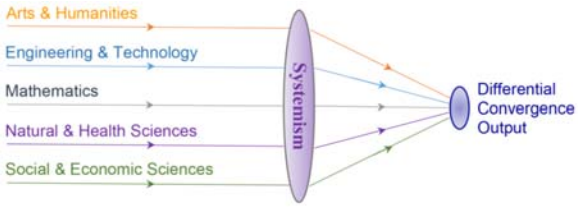

Figure 2. Convergence, especially of disciplines from different fields and different realms, is optimized when carried out through systemic lenses.

Systemism is a worldview according to which the entire physical world, from the astronomical scale to the subatomic scale, humans and their societies and various institutions included, as well as the conceptual realm of human thoughts and academic disciplines, are all considered to consist of systems of well-defined structure and function (Bunge, 1967, 1979, 1983, 2000; Halloun, 2019, 2020a, and references therein; Johnson-Laird, 2006). Among other important things, a systemic worldview helps bringing out patterns in both worlds, physical and conceptual, which further facilitates finding common grounds among various disciplines. A *pattern* is a common feature or a regularity in space and time, human brain and mind included, that we may identify in the structure of things, especially systems, or in processes, events, and phenomena (behavior) they are part of. Hence, convergence can be made easier and more efficient when systemic, i.e., when carried out with systemic convergence lenses or systemic frameworks, especially when implicating disciplines from different fields and different realms (Fig. 2).

Many reformists in education have already acknowledged the importance of a systemic worldview on all aspects of our life and called for "systems-level" or "system-based" understanding of various disciplines taught at different levels of education (Garcia et al., 2014; Goleman & Senge, 2014; Johanessen, Olaisen & Olsen, 1999; Laszlo, 2015; Liu et al., 2015). As a consequence, some educators have been integrating "systems thinking" or "systemic thinking" in their teaching. As a consequence, the quality of students' knowledge is significantly enhanced, especially in terms of coherence and consistency within and across disciplines, and their capacity to successfully and efficiently deal with real world situations

(Assaraf & Orion, 2005; Cárdenas et al., 2010; Hmelo-Silver, Marathe & Liu, 2007; Mehren et al., 2018; Rodriguez, 2013; Sosa et al., 2010; Waters Foundation, 2010).

Systemic convergence is especially important in education. It can be readily realized with any modality of differential convergence, even in the context of disciplinary curricula (discipline-based). Systemic convergence is of course more efficiently realized if these curricula are systemic, and if not, if at least the content implicated in convergence is explicitly re-constructed around convenient systems. A systemic curriculum is designed around a limited number of systems drawn from the respective discipline(s), and is systematically implemented as being about system construction, deployment, evaluation, and regulation. Curriculum design and deployment must then be done under a systemic pedagogical framework, a framework with systemic cognitive premises and systemic disciplinary premises, like Systemic Cognition and Education (SCE).

SCE is a generic pedagogical framework for student and teacher education (Halloun, 2020a). It is grounded in educational research and related research in cognitive science, and especially neuroscience. According to SCE, cognition and formal education at any level can be most efficient when conforming to the natural structure and processes of human mind and brain that consist respectively of conceptual and nervous systems, and concentrate in cognition on systemic patterns in human thought, academic disciplines included, and the physical universe. Any educational curriculum of any type and any level must then be about systems commonly defined, in any discipline, in accordance with the same schema or template, and students must learn to construct them and deploy them following systematic schemes provided in SCE. Schema and schemes are presented with ample details elsewhere (Halloun, 2020a & b). We simply outline the schema here to get a quick idea about how a system is defined in SCE.

4.1 System schema

In simple terms, a *system* is a set of entities that interact with each other, or that are connected or related to each other, in specific ways in order to serve particular purposes or functions under certain conditions. The system is *conceptual* if it consists of abstract entities of human thought that we can communicate with each other. It is *physical* if it consists of concrete or material entities of the physical world, biological systems like the nervous system included. Depending on our interest, we may also consider social, psychological, economic, and other types of systems, each type of which makes the object of a particular academic field or discipline.

A system of any sort and any complexity is defined in SCE in accordance with a four-dimensional schema (Fig. 3) that specifies the system's framework, scope, constitution, and performance (Halloun, 2020a). The framework governs system construction or delineation, and more precisely the specification of the system scope, constitution, and performance. It also governs subsequently the deployment of the system, i.e., its use in particular situations for some or all the purposes it is supposed to serve, as well as its continuous evaluation and regulation. The same schema may also be used to define any subsystem or part of a system, individual conceptions of academic disciplines included.

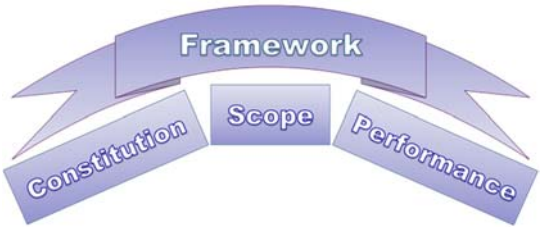

Figure 3. System schema.
Reproduced from, and details at:
www.halloun.net/sce/

1. The *framework* of a system that governs system construction/delineation and deployment consists of all foundational premises typically chosen or derived from the concerned disciplinary paradigms[3].
2. The *scope* of the system specifies the domain in which it exists, and the function or purposes it serves in that domain.
3. The *constitution* of the system lists primary or pertinent entities the system and its environment (influential surrounding settings) consist of, and specifies how these entities interact with, or are connected or related to, each other.
4. The *performance* of the system specifies the processes it goes through (operations, mechanisms, maneuvers, etc.), and the output it brings about subsequently (object or process, concrete or abstract, conservation or change of a given state or event, etc.).

4.2 Systemism advantages

According to SCE, the human mind and brain consists respectively of conceptual and nervous systems that constantly interact and affect each other to sustain our constant intellectual development. Any learning experience, whether for self-fulfillment or for fulfilling outside requirements, would then be most efficient if it proceeds systemically, i.e., as system-based, especially if it is an experiential learning experience that is about transactions with real world systems (Halloun, 2004/6, 2017, 2019, 2020a).

A systemic worldview brings about many cognitive advantages especially in formal education as discussed at length elsewhere (*ibid*). Among others, it brings epistemic coherence to students' conceptual knowledge and methodological consistency to their procedural knowledge within and, especially, across different disciplines, which is a primary objective of convergence as promoted in this paper. In particular, the following advantages can be noted in this respect.

1. Ontological-epistemological consistency:

Our transaction (cognitive interaction) with any concrete or abstract reality involves continuous negotiations between the reality and the corresponding conceptual image we build in our mind to represent the reality in question (Halloun, 2017, 2019). As negotiations proceed, the conceptual image changes, and so does all knowledge we invoke from our memory in the process. The output, regulated image and invoked knowledge, is most effective and meaningful, and most accessible and productive in subsequent transactions when there is some sort of isomorphism between reality and image (Halloun, 2004/6, 2017, and references therein). This may be best achieved when reality and image are both treated as systems, and deliberate mapping between the two is explicitly done at the level of scope, constitution, and performance of each under a systemic framework like SCE. Consistency would then be maintained from an ontological perspective between realities and corresponding conceptual images (in accordance with the system schema), as well as from a related epistemological perspective with and within related knowledge in our memories. Such consistency has the advantage of optimizing the process and outcome of our transactions with the outside world, and especially our access to, and deployment of, necessary knowledge already in memory during transactions and beyond. It especially has the advantage of facilitating the convergence of knowledge about a given system adducted from different disciplines.

2. *Order in our thoughts and actions:*

Cognitive and behavioral order begins by concentrating on patterns in both the physical world and the conceptual realm of our memories, and revealing patterns systematically in the former world through a systemic worldview. Our long-term memories consist of conceptual patterns sustained in neurological patterns in our brain, and no new knowledge (no new conceptual image) can make its way to long-term memory, and subsequently accessed there, unless it can be readily integrated with existing conceptual patterns by concerned neurological patterns (Halloun, 2017, 2019, and references therein). Pattern-based conceptual order in our memories and thoughts, leading to practical sensorimotor order in our perceptions and physical actions, is best ensured through systematic recourse to systemism. The convergence of systemic patterns adducted from different disciplines is facilitated when various patterns are contrasted and brought together systematically, and to the extent that is possible, at the level of every facet of the four dimensions of the schema of Figure 3.

3. *Plasticity and dynamism:*

Conceptual systems are plastic in their constitution and dynamic in their performance. No conceptual system is absolute and final. Its constitution is constantly regulated, its performance constantly enhanced, at least in precision and approximations, and its scope constantly refined subsequently. This stems from the fact that our mind and brain are plastic and dynamic in nature. They continuously evolve, whether or not engaged in experiential transactions with the physical world, thanks primarily to the inherent dynamism of neural networks that keep working for more and better associations within and between different cerebral areas (*ibid*). Such mental and especially cerebral dynamism and plasticity allows for continuous knowledge regulation and evolution, evolution that is optimized when carried out systematically with a systemic worldview. It especially allows for the comparison and regulation of knowledge about a particular system or related systems adducted from different disciplines in view of systemic convergence.

4. *Holism:*

Holism is, for us, about the added value that a system as a whole brings to its constituents and the surrounding environment. A system is *holistic* in the sense that, as a *whole*, it is more than the sum of its parts, and those parts gain their full significance only as system constituents, just like a heap of stones gains significance when used to build a house. The system has *emergent properties* (e.g., the shape of a house) and *synergetic functions* (e.g., dwelling) that no constituent (a stone) possesses alone outside the system. The two holistic features may not be attributed to individual parts and may not be fully understood and appreciated by simply breaking the system into such parts (by analysis or following a reductionist approach). Subsequently, a systemic worldview opens up new horizons for us and takes us to new frontiers that may be neither conceived nor accessible outside such worldview. This is for example the case when convergence of systemic knowledge from different disciplines is envisioned with a certain level of integration that allows for the emergence of new knowledge and creative byproducts, like in the case of crossdisciplinarity.

These systemic advantages and more make it easier for us to see the big picture within and across disciplines in flexible and dynamic ways, and thus to cross boundaries and bridge divides among disciplines. With systemic convergence frameworks (Fig. 2), any convergence modality would be carried out efficiently, even pluri- and multi-disciplinarity that require no synthesis at

all among implicated disciplines. The situation of concern would then be conceived as a situation involving interacting systems (or parts of a system), and all required disciplinary knowledge would be systematically adducted with the system schema (Fig. 3), which would help deploy this knowledge efficiently in tackling the situation in question. Most importantly, systemic convergence frameworks would facilitate systematic convergence of disciplines from different fields and different realms, especially those fields totally segregated in academia and the job market, like the ones that traditionally set apart general education from vocational and technical education.

5. Systemic differential convergence education

Convergence of traditionally distinct disciplines is an utmost necessity in education to empower students for self-fulfillment and meeting the realities of present day life, especially in the job market. To be realistic and affordable given the still prevalent discipline-based academia and educational systems, convergence education can only be differential, and to be feasible and efficient, it would better be systemic. Educational systems and curricula, especially in K-12 general education, need then to consider necessary adjustments in order to accommodate systemic differential convergence education.

As mentioned above, differential convergence education (DCE) is not about integrated curricula and not about giving away discipline-based or disciplinary education at any level. The latter education will always be needed, and so will discipline-based educational research to enhance the quality of student learning, especially to bring coherence of student knowledge within and across disciplines (NRC, 2014). However, and among many other drawbacks, conventional disciplinary curricula are overwhelmed with academic knowledge that students can live without in their daily life and the workplace, and they concentrate on epistemic and reproductive routine knowledge to the detriment of creative and innovative procedural knowledge in academia. These curricula can become more efficient and more appealing to students, and meet better the realities of the 21st century if they are revamped in at least three respects. First, they need to trim academic knowledge in accordance with the "less is more" philosophy, and concentrate more on "how" students should learn things meaningfully and deploy their knowledge efficiently and creatively in practical situations, than on "what" to assimilate by rote from disciplinary knowledge. Second, they need to concentrate more on what helps bridging disciplinary divides than what sets disciplines apart, and help students figure out common conceptual and procedural patterns and develop systematic ways for transfer of knowledge within and across disciplines. Third, they need to engage students in experiential learning experiences that help them develop the skills and dispositions of collaborative teamwork and of systematic and constructive engagement with others and the ecosystem.

A systemic perspective on individual disciplines can significantly help in this direction, and along with systemic convergence, it can especially help students realize and appreciate common conceptual and procedural patterns in different disciplines, transfer knowledge systematically across disciplinary boundaries, and infuse order in their memories, efficiency in knowledge retrieval, and creativity and innovation in handling any situation (Halloun, 2017, 2019).

Systemic DCE can be part of disciplinary education, and concerned authorities can feasibly accommodate it in their curricula, especially if revamped as mentioned above. Individual schools must then have some leeway in this respect. Depending on the situation in each school, or school district, teachers and administrators can choose the implementation strategy that suits

them best. They may choose to begin by allocating a certain number of weekly periods to convergence projects managed collectively by concerned teachers, or by including one course or more in their weekly schedule entirely dedicated to differential convergence. They may also choose a mix of both strategies, applying one in a given cycle, and the other in another cycle. Ultimately, it would be better for a school to reach a point where weekly courses can be dedicated to systemic DCE.

Whatever strategy followed, schools need to pay a special attention to a number of issues to ensure quality and success in their work. Among other major ones, the following issues are of particular importance:

1. Adopt a well-defined systemic pedagogical framework in the context of which the entire DCE and, eventually, the entire curricula are deigned, deployed, and constantly evaluated and regulated. Framework and DCE must concentrate more on generic skills and dispositions that empower students for lifelong learning, self-fulfillment, and significant contributions to sustainable local, national, and global development, than on specific disciplinary knowledge of limited utility. Moreover, digital technology must be an integral part of, not and add-on to, framework and DCE practices.
2. If curricula are not already systemic, teachers and other stakeholders may gradually infuse systemism in DCE by structuring projects or courses around a limited number of systems in accordance with the system schema of Figure 3, and take advantage of doing so to gradually transform their curricula into systemic curricula, and eventually transcend their conventional settings and practices altogether.
3. A school, a local authority, or any other individual or group of stakeholders may choose any particular convergence modality to begin with and gradually proceed through more involved modalities. However, one must always aim to reach eventually crossdisciplinarity in K-12 education, especially in secondary school, even if partially implemented, and transdisciplinarity in tertiary education.
4. DCE may gradually increase the number of implicated disciplines, beginning with those in the same field and realm, and ending with disciplines from different fields and different realms[1]. One must admit though that bringing together disciplines from different realms impose significant but worthy challenges, especially when we bring disciplines together from innermost STEM realms and outermost realms (arts & humanities, social & economic sciences) in Figure 2.
5. DCE must involve, to the extent that is possible, every implicated discipline in all its paradigmatic aspects, from foundational premises to practical epistemic and methodological aspects.
6. DCE must always relate to everyday life in matters that concern students and their communities, especially in relation to individual and community welfare with an eye to global issues and the ecosystem at large.
7. DCE must strive to bridge the traditional divides between general education and technical and vocational education in ways that bring it as close as possible to the realities of the job market and the practical needs of everyday life. It must especially focus on themes that help students develop at school enough knowledge about the prospects and required qualifications of potential careers, so that they would not waste time and money figuring out what major to go for in college / university.

8. DCE must engage the local community (with school-school and school-university partnerships) in at least two respects. First, students must have assignments that take them outside the school walls into the community, and that require apprenticeship or at least limited internship in concerned productive sectors, especially in secondary and tertiary education. Second, those sectors must take part, as complete stakeholders, in the design and implementation of DCE in order to keep schools, universities, and job market in synchrony.
9. Teachers and administrators must adopt viable means for documenting and tracking individual student progress throughout all school years, interpreting the progress against expected realistic tracks, and regulating instruction and learning accordingly. This requires moving away from traditional testing, high-stakes exams, and assessment "of" learning, toward assessment "for" and "as" learning (Halloun, 2020a).
10. A proper monitoring and support system (with proper incentives) must be in place to ensure, among others, proper training of teachers and administrators before DCE implementation, continuous professional development afterwards, efficient sharing of best practices (through some sort of "communities of practice" like professional learning communities, PLC), and especially timely and efficient intervention when needed. Moreover, the system in question must empower stakeholders to heed and meet any challenge that may arise, including unprecedented qualifications and needs that could eventually emerge in the job market and various aspects of life.

Convergence that has always been around in one form or another for tackling specific issues, or even bringing about new disciplines in academia, is gradually becoming a sweeping reality in the job market and other aspects of life, especially where creativity and innovation are the norms. Realistic convergence modalities are thus urgently needed in education, especially K-12 discipline-based general education, to help students meet present day realities in all conceptual and practical respects. This white paper offers some guidelines for systemic differential convergence in five modalities that can take place progressively in any sector, especially the educational sector, with ultimately crossdisciplinarity and transdisciplinarity in view for secondary and tertiary education respectively. To this end, teachers, administrators, and other stakeholders in education are expected to break away from idle tradition, think outside the box, and come together for creative and innovative convergence to revamp their curricula accordingly, and empower themselves and their students to make significant contributions for sustainable local, national, and global development. Policymakers and concerned authorities need then to ensure that all concerned parties are motivated and supported well enough to deploy and sustain necessary efforts for systemic differential convergence education and beyond.

Supplement: Guidelines for systemic differential convergence education

A supplement that offers general guidelines for the design and implementation of systemic DCE projects is available at:

http://www.halloun.net/sce/

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