Profiling interdisciplinarity in higher education: an ecological approach

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Filipa M. Ribeiro and João Bettencourt Relvas

The purposes of this paper are to describe a major program of research on interdisciplinarity: the "profiling project", based on an ecological or interactionist approach to interdisciplinarity and to outline several important implications of this research for theory and practice. The explicit focus of this program of research is on the continued development and application of an operational approach to interdisciplinarity. We will offer a working definition of profiling, describe several major questions currently prone to be investigated, and suggest possible implications of this program of research for theory and practice.

Key words: interdisciplinarity, higher education, profiling, ecological approach.

Introduction

Interdisciplinarity is been increasingly fashionable at academia. In September 2003, ministers "took into due consideration" the Lisbon agenda" (Berlin Communiqué 2003, p. 2) and:

> "conscious of the need to promote closer links between the EHEA and the ERA in a Europe of Knowledge, and of the importance of research as an integral part of higher education across Europe, [they] consider it necessary to go beyond the present focus on two main cycles of higher education to include the doctoral level as the third cycle in the Bologna Process. They emphasise the importance of research and research training and the promotion of interdisciplinarity in maintaining and improving the quality of higher education and in enhancing the competitiveness of European higher education more generally". (ibid., p. 7)

Also, one of the focus of the document issued by the Commissioners for Education, "Delivering on the Modernization Agenda for Universities: Education, Research and Innovation" (CEC, 2006), was to have a rather different message, "enhance

interdisciplinarity and transdisciplinarity," which requires to focus less on scientific disciplines and more on research domains.

This focus on a broader range concept of interdisciplinarity draws attention towards two aspects to be considered: 1) the need for an extra effort to promote the formation of a cohesive research team involving researchers from different disciplines, to combine expertise from several knowledge domains and to overcome communication problems among researchers from different disciplines; 2) the way the trend affects early career researchers undertaking their master or even PhD degrees, namely in what regards the institutional support for that type of research. There are many good researchers doing valuable work, but there is not a follow-up on the institutional side. Despite universities and funding bodies paying lip service to the concept of interdisciplinarity, academics report their interdisciplinary work being excluded for being "too risky" or "out of the box" or even "not with an immediate application". Also, high impact journals are less inclined and able to assess diversity among and within disciplines. Likewise, taking on teaching responsibilities, essential for those wishing to pursue an academic career, can be problematic when you cannot prove yourself experienced in just one single subject area. Creative ideas need a receptive audience to record and implement them.

On the other hand, many of the now-popular centres for doctoral training, which attracted a recent boost in government funding, have a strong interdisciplinary ethos, with students working for multiple supervisors in different departments, on projects that are hybrids of multiple subjects. Though there is a positive side of this, there is also the other side of the coin: a lack of support and guidance and the risk of students getting lost in translation and ending up being an expert on nothing. In addition, scientific structures and knowledge are still highly dependent on experts and most epistemic changes on disciplinary knowledge is dependent upon experts.

One of the main dilemmas concerning the pursuit for interdisciplinarity is that it can seldom, if ever, bridge completely the gap between the micro and the macro as well as that between different conceptualisations of the object under investigation (see Weiss and Wodak, 2003). One can only attempt to integrate different approaches or to relate them as closely as possible (Fairclough and Wodak, 2008:134). Though these authors emphasize the institutional aspects of interdisciplinarity, there are other dilemmas

concerning the practicality and conceptualization of the term, which we will briefly overview in the next section.

Interdisciplinarity at educational settings

"... scholarly disciplines, however they may have evolved in recent times, began because of human beings' interest in understanding diverse aspects of their world — ranging from the movement of the stars to the strivings of the soul" (Howard Gardner, professor of cognition and education at the Harvard Graduate School of Education, Chronicle of Higher Ed, July 9th 2018).

Interdisciplinarity is often associated to the integration of disciplinary perspectives (e.g., Birnbaum; Cotterell; Hanisch and Vollman; Hausman; Klein; Kockelmans; Epton, Hermeren). But this gave rise to one of the main arguments against interdisciplinarity: that it rests upon serious conceptual confusion. That said, as Benson notes:

"each of the disciplines offers us some general criteria for locating questions inside or outside of its boundaries. For the most part, the boundary lines among the disciplines are drawn by means of appeal either to a distinctive subject matter or to a distinctive method of inquiry" (Benson, 1982:39).

In fact, the most known use of the term draws the attention to a concatenation of different disciplines or their components (e.g.: Rossini and Porter, 1979). Fairbam and Fulton (2000) define it as a problem-based approach in which knowledge and methods are brought to bear as needed to solve a complex problem or to address an object study. It is a response to a felt need insufficiently addressed by solely disciplinary work; an identification of a gap of the university's mission and its surrounding community. However, this problem-based definition may erroneously dichotomize disciplines and interdisciplines, confuse specialization and synthesis, and misconstrue 'integration'" (Graff, 2016).

On the other hand, interdisciplinarity demands constant proactiveness, responsiveness and the ability to adapt to changing situations. Andersen and Wagenknecht (2013) also remind that interdisciplinarity involves: epistemic dependence between researchers with different areas of expertise, the combination of complementary contributions from

different researchers through shared mental models and conceptual structures, and shared cooperative activity with interlocking intentions, meshing sub plans and mutual responsiveness. Some authors understand interdisciplinarity as "any form of dialog or interaction between two or more disciplines" while minimizing, obscuring, or rejecting altogether the role of integration (Moran, 2010:14). While others adopt a more integrationist approach advocating the reduction of the semantic evasiveness surrounding the term interdisciplinarity and pointing to research in cognitive psychology that shows that integration is both natural and achievable (Newell, 2007:245; Vess & Linkon, 2002:89). These might sound vague definitions, especially in times when a growing crisis in the planning and politics of the undergraduate curriculum is taking place. Alongside there is the spread idea that disciplines are silos and closed cloisters and that is why interdisciplinarity is needed. But, for instance, studies on the emerging field of nanotechnology or even neurosciences suggest that rapid growth leads to internal differentiation. Schummer, for example, concludes that nanotechnology's "apparent interdisciplinarity consists of largely mono-disciplinary fields, which are rather unrelated to each other and which hardly share more than the prefix 'nano'" (Schummer, 2004:425).

Ribeiro (2016) contends that interdisciplinarity is deeply embedded in institutional arrangements and that researchers' networks of relations strongly influence interdisciplinarity. That influence mirrors processes of personal and institutional adaptation, resistance, hindrance or enhancement of interdisciplinary research.

On the other hand, traditional perceptions on education are being challenged by the changing scenery of the times. There is a discrepancy between the reputation of the University in academic terms and its actual distributed weight in job market output, particularly in technical fields: for instance, despite its classification as a world-class research facility, Cambridge boasted an employment rate of only 95% for recent graduates, seventh-place overall in Britain in a Telegraph ranking (number 1 was Robert Gordon University).

Traditional universities are entering the game late and finding themselves increasingly superseded by smaller and more dynamic institutions in the marketplace, which are more achievement-oriented (patents, start-ups, spin offs, etc). The rigid curricula of brick-and-mortar schools is often at odds with the flexibility and accessibility of online education.

The value of diplomas is no longer translated into direct employability, if it ever was, and is arguably an indication of academic achievement rather than a skill certification.

In the past few decades, universities have sought to bridge the education vs job market rift by establishing partnerships, and nowadays companies are looking to draft promising staff before they even hit the job market. However, this is not a sustained effort that supports the educational tidings as a whole: rather, it is more about cherry-picking individuals rather than assisting the new generation of workers.

Conventional wisdom would seem to suggest that the main employability problem lies with lack of experience in a specific field. Germany countered this with a dual vocational education system that allowed the country the lowest unemployment rate for under-25s in Europe. The dual education system also allows companies to train future employees literally at apprenticeship level, but this tendency is now changing, as companies are increasingly reluctant to invest time and money in under-trained student-workers for positions whose complexity and flexibility is increasing. Also, skills learned on-the-job can become outdated quite quickly.

This highlights the main problem with traditional education: it confronts students with a mainly monolithic curricula that does not stimulate skill training or problem-solving, but rather serves as an inflexible reminder of the inadequacies of institutionalised learning. Neither the students nor the companies benefit from this, since the student's incentive to learn and update their knowledge throughout their professional lives is minimised through early employment and practical professional adaptation.

Students should not be funnelled into a specific skill set in order to achieve a greater depth of specialization in contrast to a wider breadth of knowledge. Youths are cast into the mould of formulaic knowledge, rather than understanding basic forms and processes. In other words, we invest educational time primarily on labelling and recalling what, instead of understanding the method, process, and how.

This is where the case for interdisciplinary thought lies: identifying and capitalising early on thought skills, rather than invest years on specialisation. A bespoke educational model based on individual profiling is not unfeasible: schools keep detailed information on their

students since pre-primary schooling, and their inclinations and talents are easily detectable at early ages. Nurturing that at an early age should be the main stream of the education flow, rather than the exception.

In a nutshell, in any interdisciplinary endeavour there are five levels to consider:
- Content level
- Knowledge level
- Institutional level
- Individual level
- Creativity level

But, foremost, there is an urgency to clarify what interdisciplinarity really means, how it can be translated into educational settings and where to start when trying to bring research on the topic to a more specific and operational level.

An ecological approach to interdisciplinarity research: profiling for interdisciplinarity teaching

Interdisciplinarity is not a term that simply describes a category or kind of person. Rather interdisciplinarity has been viewed by many as a multi-faceted phenomenon which results in the production of new and useful ideas. Interdisciplinarity, therefore, can be viewed as the result of interactions among several important components or dimensions of knowledge production.

The purposes of this project are to describe and implement a major program of research based on an ecological or interactionist approach to interdisciplinarity and to outline several important implications of this research for theory and practice. The explicit focus of this program of research on the continued development and application of interdisciplinarity is a descriptive process model which can be used to define or formulate problems, generate ideas and refine solutions for implementation.

We will begin by reviewing historical research on interdisciplinarity and curriculum that led to and shaped the current research initiative. We will offer a working definition of profiling, describe several major questions currently under investigation and suggest possible implications of this program of research theory and practice.

Historical background and rational

Interdisciplinarity as a concept and a practice is one of the most hotly debated topics among academics and has spun a complex web of development strategies and theorizing. However, its lack of standardization continues to be an issue, namely in universities that have traditionally hermetic departments and a lack of communication embedded in the academic culture.

To define interdisciplinarity is always controversial. According to Olga Pombo (2006), interdisciplinarity is mainly a practice reflected in the achievement of different types of interdisciplinary experiences of research at universities and laboratories, on experimentation and on the institutionalization of new systems of organization. Fairbam and Fulton define it as a problem-based approach in which knowledge and methods are brought to bear as needed to solve a complex problem or to address an object study (Fairbam & Fulton, 2000). It is a response to a need insufficiently addressed by solely disciplinary work; an identification of a gap of the university's mission and its surrounding community.

Some of these problems stem from the fact that interdisciplinarity is frequently linked to the end-of-chain stage, interspersing time constraints with role diffuseness, leading to severe quality compromises in most cases. Despite the fact that interdisciplinarity is present both on a discoursive level and valued by researchers, the reality often translates this:

> "I sit, once again, on a committee evaluating grant proposals that have to meet explicit criteria of interdisciplinarity. As usual, the committee is interdisciplinary in the sense that it is mostly made up of scholars from several disciplines, each recognised and powerful within his or her one discipline. Very few of us have been involved in intensive interdisciplinary work. Most of the grant proposals we have to evaluate have built in interdisciplinary rhetoric and describe future collaboration among people from different disciplines, but this is mostly done in order to meet the criteria for the grant. The actual scientific content generally consists in the juxtaposition of monodisciplinary projects with some effort to articulate their presentation. A few proposals are genuinely interdisciplinary, but often they are the less well thought through, the least likely to yield clear results.

> And now we have to rank two proposals: a really good proposal the interdisciplinary character of which is superficial and ad hoc, and a merely decent, but genuinely interdisciplinary and innovative proposal" (Sperber, 2003).

Thus, an important critic and drawback for interdisciplinarity is that, in projects in areas like neuroscience and nanotechnology, it is perceived as a way to generate streams of grant support. But, often, interdisciplinarity is also a way to produce efficiencies, stretching academic resources by focusing energies on common efforts (Brint, 2009).

Interdisciplinarity demands constant proactiveness, responsiveness and the ability to adapt to changing situations. As Sperber (2003) notes, often disciplinary boundaries and routines stand in the way of optimal research and that is why the solution is to go ahead with new research programmes, which requires institutional reshaping. A less debated dimension of interdisciplinarity concerns the individual and social epistemology of knowledge and science. Andersen and Wagenknecht (2013) remind that interdisciplinarity involves: epistemic dependence between researchers with different areas of expertise, the combination of complementary contributions from different researchers through shared mental models and conceptual structures, and shared cooperative activity with interlocking intentions, meshing subplans and mutual responsiveness.

In sum, the case exposed by Fairnam and Fulton highlights the need to adapt to circumstances within reason of the context, both mentally and physically. As Gumport and Snydman (2002) propose, the academic structure of a university plays a big role in shaping the boundaries and character of knowledge for those who work in the institution. The problem is that such academic structure does no longer support the common belief that individuals can disinterestedly collaborate with one another and construct interdisciplinary research.

The emphasis on productivity and competitiveness produce an ideological system that serves the economic regulation at universities, encouraging an overemphasis on research projects and courses (e.g.: the proliferation of summer schools), which have to be described as highly interdisciplinary in order to get funding but without actually giving room of manoeuvre so that research groups deal with changing needs and requirements

that such type of research requires. Obviously, in the face of this increased turnover on interdisciplinarity, there is a compromise in the efficiency level of the institutions, but the increased emphasis on presenting profits with minimum transition periods ensures that institutional and group decisions are based on shorter timespans, instead of long-term investments, just like it happens in the corporate world (Mintzberg and Van Der Heyden, 2002).

Researchers and higher education institutions are now faced with a multitude of pressures that were absent from the workplace decades ago. Those pressures have prompted considerations on the "new capitalism", in which the social system and the economic system have blended into a new ideological system where individualism reigns (Sennett, 2006). However, the actions of these individuals are as pervasive to themselves as to the social environment in which these actions are embedded. Modern universities equate these social systems by stabilizing the output ratio of staff production through more specific management methodologies and policies or rules that encompass human interactions and professional skills. Braverman (1974) argued, armed with a Marxian class systematization, that professional skill was hindered by managerial staff by running interference on the implementation work processes. This helped to constrain the perception of the worker of the overall system, thereby rendering it vulnerable to errors and unable to perceive the deeper integration of its actions in the overall corporate system.

Plus, universities still embody key ideas of knowledge, such as specialization, status and academic careerism that resemble the privileged values of the nineteenth century, despite all the institutional, virtual and network changes that they went through. The main consequence is that departments have become a more or less arbitrary set of faculty members and researchers working autonomously of each other. So, regardless if it is public or private, the type of scholarship is always privatized and sustained upon formal pieces as the autonomy of faculty members and the autonomy of the department are indeed closely related. But if in times where the state regulation was high, that interconnection served as a shield against outside interference, nowadays, though, faculty departments find themselves lost in translation. The new governance modes and the new configurations of the so-called knowledge society forces them to be more flexible, movable, but still they do not show an active collective purpose and, thus, they lose their strength.

The question is, then, to know if and how interdisciplinarity can provide a source of competitive advantage. Michael Porter (1990) has argued that nations derive competitive advantage from a set of country-level factors such as the availability of resources, the size and sophistication of the market and the type of strategic linkages or networks. In a similar manner, this paper contends that interdisciplinarity, although difficult to separate out, is deeply embedded in institutional arrangements and researchers' networks of relations. What is missing is that interdisciplinary research and institutional configurations work interactively to create potential competitive advantage for institutions and for Science. Many examples could be mentioned ranging from the innovation systems based on the relation university-industry and the criticism to the grandes écoles in France to more concrete examples as the debate about Area studies in the Arts Faculty of Leiden University (Zürcher, 2007).

The dynamic nature of interdisciplinarity

Although it has often been observed that interdisciplinarity involves the simultaneous interaction among elements of personality characteristics, cognitive abilities, behavioural or biographical events associated with individual work or performance, there is also an environmental factor linked to institutional arrangements. Past research dealt with the multi-faceted nature of interdisciplinarity primarily by attempting to separate it into manageable areas of investigation. This separatist approach enabled researchers to focus their attention solely on variables within a specific dimension, without concern for potential interaction effects created by other variables. Further, within each dimension, researchers often employed a reductionist approach. The major goal of many early investigations was to reduce one dimension of interdisciplinarity to the most fundamental or basic variables that would best predict interdisciplinarity in a broader or more general conception. This approach allowed researchers to manage the dynamic nature of interdisciplinarity, but it lacks operational precision and it did not reflect adequately the multi-faceted nature of the phenomenon of interdisciplinarity. Moreover, prior research has not yet clarified our understanding of many important variables within each dimension by separating the four themes or dimensions mentioned above for the purposes of systematic investigation. In other words, few researchers have explored how aspects of the person, the processes they use, the institutional constraints, and the qualities of the outputs they create interact to yield varying levels and styles of interdisciplinary

productivity. And this explains why authors, such as Jerry Jacobs (2009), believe that "efforts to reorganize academe based on interdisciplinary principles would have disastrous consequences in the short term—and would end up reproducing our disciplinary or departmental structure in the long term".

In relation to interdisciplinarity, one can identify three broad stages or historical waves of research and development. These are: a) process development; b) linking process to person and institution; c) an ecological approach.

Learning and cognitive styles

A major aspect of work to understand interdisciplinarity is to explore individual differences and how they can affect and link to interdisciplinarity through the examination of learning and cognitive styles. Wittig (1985) and McEwen (1986) studied relationships between learning styles and various measures of divergent thinking and feeling. McEwen's results, for instance, showed that students with different learning styles expressed their creativity in varying ways. Isaksen has also initiated a research program called Cognitive Styles Project aimed at examining the nature of the interactions between preferred ways of processing information and creative problem-solving behaviour. But the search for reliable and valid measures of individual difference variables that might be particularly germane to the study of interdisciplinarity continues. One still lacks instruments well supported by theory and research that can serve as sources of data for our continuing studies of the interaction between individual difference variables and process dimensions.

Style and level of interdisciplinarity (or where to begin with)

In drawing the distinction between style or preference and level or capacity, the theory which so far has received the greatest attention has been Kirton's Adaptor-Innovator distinction. Kirton (1976:1989) consistently maintained that his cognitive style theory and measure are unrelated to creative capacity or level. His theory posits two styles: the adaptative style which is characterized by working within the system to improve it, while the innovative style is described as challenging the current system or paradigm.

Several other studies demonstrated important links between person and process variables. Rickards and Puccio (1992), for example, showed that adaptors believed their greatest

contributions in applied problem solving occurred during the convergent phases, whereas innovators maintained that their best contributions came during the divergent phases. These investigations contributed significantly to our knowledge of the interaction between characteristics of people and aspects of the creative process. The rational is: once individuals understand their style preferences they understand better their natural, personal approach to thinking and problem solving. As a result, they can approach the task of learning more interdisciplinary, rather than viewing their task merely as attaining proficiency with an externally –imposed, fixed set of techniques. They can assess their own process strengths and needs more effectively. In addition, as individuals become aware of various style orientations, it becomes easier for them to understand and accept the principle that there is more than one 'right way' to acquire knowledge.

Although the results of research up to this stage did enhance instructional efforts regarding interdisciplinarity, it became clear that the person-process interaction only addressed some of the dynamics in understanding interdisciplinarity and creative productivity.

An ecological approach

Through our present and emerging research, we seek to discover more about the nature of interactions among any relevant contingencies and their implications for education and teaching and future developments for interdisciplinarity research itself.

Our methodology for dealing with these challenges can best be described as an interactionist or ecological approach. We are concerned with the interaction of several variables within a specific context, very much like the ecologist who explores the interactions among living and non-living components within an ecosystem. One of our explicit goals for our emerging research agenda is to understand better and build more effectively upon the multifaceted nature of creativity through interactionist rather than reductionist methodologies. Our goal is to understand the natural interactions among the sources that lead to interdisciplinary teaching. We believe that too many previous investigations have artificially separated interdisciplinarity for analytic or convenience, into separated isolated topics of study (e.g. focusing only on person or on process). Unlike the blind men in the well-known parable, we seek to study the whole elephant not just its parts.

Profiling interdisciplinarity: an expanding concept

The term 'profile' has often been construed only in a narrow, limited view to represent a summary or sketch of an individual's traits and abilities. The customary image of a profile is a transcript or a series of scores. In some cases, there might be an emphasis on the importance of gathering data form several sources (as for example in the common admonition to use 'multiple selection criteria' in educational settings).

Our continuing research efforts will initially employ the following definition of profiling: profiling refers to the development of a multi-dimensional framework to help understand, predict and facilitate creative and interdisciplinary education. This framework takes into account a constellation of meta-cognitive, cognitive and personality characteristics; dimensions of situation, such as institutional setting and culture; elements of task, process behaviours, and outcome qualities.

This approach to profiling builds upon the ecological and interactionist views regarding creative productivity and marks what we believe to be a unique and significant departure from some more popular uses of the term. To clarify further the nature and implications of an expanded conception of profiling, two important premises clearly emerge and must be addressed.

First, interdisciplinary education does not come about (or fail to come about) only as a result of what is present (or absent) within the individual; it is influenced by time, other people, places, settings, domain-specific knowledge and strategies that people can use individually or in groups. Therefore, no one is, in an absolute sense, always more or less interdisciplinary and one should not 'look for' interdisciplinarity as something fixed and static; it waxes and wanes dependent on a combination of multiple factors. Thus, the goal of profiling is not to ask "How interdisciplinary is this person? "It is not just to aggregate several independent data sources in order to obtain an overall index or categorization of the person. Rather, it is to help identify, for a particular task or goal, in a certain setting and under particular circumstances, the person's disciplinary strengths or talents, the best ways to put them to use, and plans to enable us to incorporate those talents into a meaningful and effective instructional or training experience.

Second, interdisciplinarity can be actively and deliberately employed, monitored, and managed. Interdisciplinarity can be nurtured and enhanced. Research has demonstrated that specific process tools and strategies can be used to increase creative-thinking skills (e.g.: Basadur et al., 2000; Baer, 2003; DeShryver, 1992). Process dimensions may be defined in many ways, but an individual's profile reflects a particular set of process skills. The exact nature of the targets or goals of the profiling effort must always be clearly specified.

Figure 1 represents graphically the five major dimensions we believe should be considered in an ecological view of interdisciplinarity. Since we are concerned with ways of understanding, predicting and facilitating interdisciplinarity, there are a set of potential dependent variables for future research. Then we will describe the five dimensions that will influence interdisciplinarity. These represent potential independent variables for future research. The variety of constructs and variables contained within a framework about research on interdisciplinarity provides a rich source of potential for ecological research. The same variety that leads to rich potential also creates several significant initial challenges in establishing the foundation for ecological research. We must begin by identifying gaps in our knowledge and understanding of interdisciplinarity; these gaps represent opportunities for development, rather than obstacles to research progress. In order to create and use an ecological profiling approach to interdisciplinarity as productively as possible, we must be able to define clearly and represent appropriately an important set of variables – the underlying skills, cognitive processes and preferences associated with, and distinguishing among, the elements of interdisciplinarity. We must establish reliable, valid and authentic methods to assess these variables and constructs.

Therefore, the development of assessment procedures for interdisciplinary courses and education criterion variables will be one of the first undertakings within this new research program. Once clear and distinct skills have been identified, the interactions can be clearly interpreted in light of each stage of the process of interdisciplinarity. For instance, one can postulate that there may be an interaction between individual's style of creativity, the nature of disciplines, and their perception of the psychological climate of their workplace/institution on problem-finding behaviour.

Figure 1 - An ecological view for interdisciplinarity research
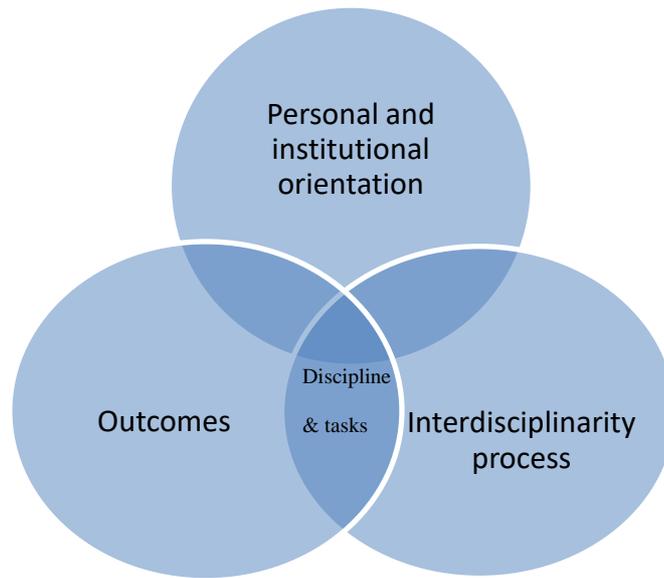
Because we are proposing a broad definition of profiling to understand, predict and facilitate interdisciplinarity, we will briefly review each of the five dimensions of possible independent variables for future research. In particular, we present in table 1 a number of illustrative contingencies for each dimension. In addition, since profiling reflects an interactionist approach, we will attempt to describe each dimension in terms of its potential interactions with other dimensions.

Table 1: Interdisciplinarity profiling contingencies

Personal Orientation	Situational Outlook	Discipline and Task	Interdisciplinarity Process	Outcome
Style	Psychological climate	Importance	Flexible, descriptive approach	Concreteness
Competencies	Cultural values and norms	Kind and degree of ownership	Divergence-convergence balance	Novelty

Motivation	Organizational culture	Ambiguity	Components	Completeness, resolution
Gender	Predominant leadership styles and behaviors	Complexity	Stages	Synthesis, stylistic quality
Personality traits or characteristics	Reward systems and structures	Novelty	Tools	Diffusion
Knowledge base and expertise	Resources and support	Projected timeline	Discipline characteristics	Impact
Teamwork values and skills	Strategic orientation	Involvement of others	Facilitation qualities	Marketability
Habits, barriers and blocks	External constraints (real or perceived)	Vision of desired future state	Resource group attributes	Satisfaction (energy, enjoyment)
Commitment and attitude toward interdisciplinarity	Current conception of domain work	Others	Experiential learning	Others
Others	Others		Others	

Personal orientation includes what is traditionally thought of as characteristics of the creative person as well as the creative abilities associated with interdisciplinarity. These include personality traits traditionally associated with interdisciplinarity such as openness to experience, tolerance to ambiguity, resistance to premature closure, curiosity and risk-

taking, among others. They also include such creative-thinking abilities as fluency, flexibility, originality and elaboration. One's expertise, competence and knowledge base also contribute to interdisciplinary efforts. In addition, recent research has shown that personal orientation contingencies must include several aspects of the person's cognitive and learning style. Furthermore, this dimension also examines individual's orientations to the four dimensions, such as their commitment and attitude toward interdisciplinarity or their expectations concerning the desired outcome.

Situational outlook involves many elements surrounding the context in which interdisciplinarity occurs. These contingencies include an individual's perceptions of the organisational culture, the predominant leadership styles and the nature and function of the reward systems and structures. Individual's perceptions and conceptions of their work and the overall strategic orientation are also important aspects of the situation. The ways individuals understand and react to their situation also lead to variations in assessing and selecting tasks.

Our ecological view departs significantly from past interactionist descriptions of discipline (Biglan, 1973) and includes a task dimension. It encompasses the general domain within which interdisciplinarity will be present and includes a description of a desired outcome. Considering the task dimension permits qualification of the context, the problem solver and the appropriate use of interdisciplinarity as an educational framework. The extent to which the task is ambiguous, complex or novel may influence the approach to discipline.

Defining a specific focus for profiling (be it problem solving, novel knowledge creation or other) offers several advantages. A complex, multi-faceted profiling approach becomes relevant and essential only when one's view of interdisciplinarity as a process framework has also become more sophisticated. Further, the comprehensive nature of interdisciplinarity provides a fertile forum for interactionist investigations. The researcher can examine interactions at several levels.

The outcome dimension refers to the results of process. Outcome contingencies differ from task contingencies in that the latter relate more to the initial or desired results. Outcome contingencies deal with the actual or real results of the interdisciplinary process.

These may be tangible (e.g. concreteness) or intangible (e.g. satisfaction). The nature of results can be considered from the point of view of the product or outcome itself or by how well it is diffused and accepted by others. Outcomes can also be assessed for their level of novelty, usefulness and other criteria. Outcome contingency may be affected by the level of ownership found in the task dimension. The desire for certain outcome qualities, such as novelty, usefulness, or completeness, may be influenced by elements found in personal orientation and may in turn impact the use of interdisciplinarity.

Ecological research on profiling will examine the effects of various contingencies within personal orientation, situational outlook, task and outcome dimensions, and their interactions on several constructs and variables associated with effective interdisciplinarity in education settings. Furthermore, this investigation will seek to illuminate additional variables that impact the successful application of interdisciplinarity, thereby enabling us to continue to refine an ecological understanding of interdisciplinarity. As our understanding of the interactions increase and deepen, we may also find that other variables and contingencies may be important to consider.

Implications and benefits of profiling interdisciplinarity

We view ecological or interactionist research on interdisciplinarity as an important basic research challenge, in that these efforts will help us to better understand the complex nature and dynamics of interdisciplinary processes in general. But the research can also be considered to be applied in both educational and business settings. As a result, the outcomes of ecological or interactionist research will have important implications for many trainers, teachers, researchers and other practitioners. We anticipate many positive implications for theory, development, research and practice will emerge from continuing research on profiling interdisciplinarity.

At the broadest level, these implications and benefits will be derived from explicit efforts to construct vital bridges between theory and practice. Through profiling studies, researchers can investigate interactions of the kinds that occur in real situations. The results should inform theory construction or development and provide practical guidelines and support for practitioners concerned with interdisciplinarity and education in a variety of settings.

Transferability of research results

A short-term benefit will be enhanced transfer of research outcomes. Since the interactionist methodology to be used in research (such as more advanced multivariate quantitative techniques as well as theoretically grounded qualitative approaches) will better reflect the nature of interdisciplinarity in realistic and applied settings, it should therefore be much easier to apply these findings to real situations. If this research shows, for example, what kinds of process strategies work best for what kinds of people and under different circumstances, then facilitation of interdisciplinarity in settings where these variables exist should be more predictable and targeted. A profiling approach to interdisciplinarity can help communicate specific outcomes associated with the interactions of certain factors that can be useful to professionals interested in a interdisciplinary approach to their working field in targeting application of tools and techniques.

Another potential benefit is the development of autonomous problem solvers. In other words, individuals who can develop effective metacognitive strategies based on their awareness of their own personal strengths, the constraints present in the situation, the relevant task demands, the process techniques at their disposal and the desired outcomes of their problem-solving efforts. It may be possible for individuals to learn to use optimal problem-solving and learning strategies consonant with their cognitive styles and even to learn to shift less congenial strategies that are more effective for a particular task than are their preferred ones.

Continuous improvement in an interdisciplinarity framework

Knowledge concerning the various influences that interact with interdisciplinarity will undoubtedly stimulate further theoretical development of this process model. For instance, information that suggests that interdisciplinarity is particularly relevant and useful to individuals who work in certain environments and possess particular characteristics, may foster the development of techniques that are useful for others in different circumstances.

One immediate benefit of the ecological approach to profiling interdisciplinarity may be the reconfiguring of personal orientation and situational outlook. These constructs were previously packaged within the interdisciplinarity process itself, rather than being seen as

important and independent concepts. Continued and extended productive inquiry could result by placing these dimensions outside the confines of process but within the relevant set of contingencies. In short, findings form this ecological research approach will lead to a more comprehensive and flexible process model placed within an improved context.

An ecological approach to interdisciplinarity research will also serve to improve our understanding and use of specific terms, variables and contingencies. Better definitions and applications can result, serving to improve the clarity and precision of future research. Rather than over-simplifying and under-defining creativity, we can encourage a more comprehensive and meaningful approach for future research.

A central feature of interdisciplinarity is its dependence on the future about which next to nothing is known. Yet that is where risk and reward are located. Thus, a profiling approach to interdisciplinarity branches the problem of dealing with the unknown by suggesting ways of thinking about the past, about the relations of science and society.

Conclusion

This paper suggests a proposal for a new major program of research on interdisciplinarity. We have placed this research program within a historical context and described its major purposes and questions to be addressed. It is our intention to aim at a more complete picture of the concept of interdisciplinarity by focusing our attention on an ecological approach to profiling interdisciplinarity. By improving our understanding of the interaction of the key contingencies identified in this paper, it is our hope to encourage the development of more reflective practitioners within the field of interdisciplinarity and education.

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