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The relationship between discipline and innovation: A factor in professorial involvement in integrating pedagogical innovation

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Abstract: The existence of disciplinary culture within universities is rooted in academic tradition. The differences between the disciplines as regards the way in which they perceive and apply Scholarship of Teaching and Learning and the fact that the discipline is a conducive factor to pedagogical innovation invite to explore pedagogical innovation from the disciplinary culture perspective and to question the effect of disciplinary culture on the types of pedagogical innovation professors use. The data for this qualitative research was collected from semi-structured interviews with thirty-two professors, recipients of the Université de Montréal excellence in teaching award. I used the grounded theory analysis method which has allowed me to uncover similarities and differences between the disciplinary cultures and analyse their impact. The Hard-Pure sciences focus on pedagogical innovation related to the tools, the concept of teaching and the support schemes. The Soft-Pure sciences prefer pedagogical innovation related to tools, support schemes and professionalisation. The Hard-Applied sciences use pedagogical innovation related to tools, pedagogical approaches and professionalisation. The Soft-Applied sciences favour pedagogical innovation related to pedagogical approaches, tools, support schemes and professionalisation. Also, the greatest pedagogical innovation diversity occurs within the Soft-Applied sciences. Thus, it is time for kindling reflection on the influence of the pure versus applied science dimension on pedagogical innovation and questioning ourselves whether the discipline's relationship with innovation could be a decisive factor in professors' involvement in integrating pedagogical innovation into teaching? This study finds its significance in probing the influence of disciplinary culture on pedagogical innovation and contributing new knowledge in this field.

Keywords: Pedagogical Innovation, Disciplinary Culture, Higher Education

1. The Disciplines: From Shared Pedagogical Expertise to Pedagogical Innovation

The art of teaching, empirical know-how (Beney and Pentecouteau 2008), which is constructed daily through experience, may consequently establish itself as a conceptual and production framework for knowledge that is identical to scientific research (Boyer 1990). Particularly popular in the United States, this well-known professional development (Huber 2010) is characterised as "*the systematic study of teaching and learning processes, as well as the sharing and review of such studies*" (McKinney 2007b, p. 10) and is called Scholarship of Teaching (SoT) or Scholarship of Teaching and Learning (SoTL) (Boyer 1990). SoTL would rather akin to applied-research on classroom teaching and learning specific questions and methodologies, although university teaching is seen as a serious intellectual activity that can be evidence and outcome based. This is an action research with a research pragmatic approach of educational research. However, this is a concept that professionalises the practice of university teaching and its development in which professors sign up as "*classroom researchers*" (Cross 1986, p.13), meaning that any of us, as professor, can become researcher in teaching and learning. In other words, they invest in university research into student learning in order to facilitate advances in teaching practice by effectively making their findings public. SoTL is relevant to professors because its main purpose is at the heart of valorising university teaching to bolster the enhancement of students learning and this is where we all meet. The professor's everyday practice entails the development of teaching professional knowledge. This valuable expertise can be maximised and enriched through classroom action research and shared among peers. The Scholarship of Teaching and Learning approach offers a guiding frame to any professors aiming for a high quality of teaching.

Constructed from past experiences of American higher education, this trend encompasses programme and lesson evaluation, research-action, the reflexive practice movement, peer teaching review, traditional research in education and professors' striving for professional improvement in order to improve teaching and learning. From an epistemological perspective, SoTL can be conceptualised as an inter-disciplinary research field that is simultaneously narrower than sociology of higher education as it restricts its enquiry to teaching and learning, but also broader than sociology of higher education as it is more multidisciplinary (Kain 2005). A sociology standpoint is relevant because, for example, science teaching can be considered as a cultural enactment that encompasses the fact that individual experiences affect education and its outcomes. This allows an exploration of implications of sociology into science education for understanding the professors' role.

Unequivocally, expertise in university teaching practice and research occurs in disciplines, within all institution types, and proves to be an international and multidisciplinary experience. Nevertheless, McKinney (2013) asserts that in recent years the status of SoTL has changed in many fields and highlights that differences are appearing between disciplines in relation to the way in which this concept is perceived and applied. Thus, McKinney (2013) responds to the old international debate over SoTL development (Healey 2000) which maintains that pedagogical expertise should develop in the context of the disciplinary culture in which it is applied. In effect, significant cultural differences take shape between researchers from different faculties as regards lifestyles, educational values and teaching foci (Gaff and Wilson 1971). These are cultures of faculties that are called disciplinary cultures (Kolb 1981). The scientific disciplines form sub-environments in which pedagogical foci, and teachers' and students' expectations and perceptions differ (Smart and Etherington 1995). Professors adopt a teaching approach that is commensurate with what they want their students to learn (Ibid.) and first and foremost consider themselves to be disciplinary specialists (Becher 1989). It ensues that professors' concepts of teaching are linked to their object of study (Martin et al. 2000). Furthermore, disciplinary culture exerts an impact on professors' teaching knowledge production and validation processes (Assister 1994). However, the perception of teaching does not vary between disciplines; a good teacher remains so, whatever the discipline taught (Murray and Renaud 1995). Excellence in teaching is a well-debated subject questioning on what is a good teacher? On the firsthand "*Good teaching is getting most students to use the level of cognitive processes needed to achieve the intended outcomes that the more academic students use spontaneously*" (Biggs and Tang 2007, p. 11) or on the other hand it can be identified as an approach to teaching defining this notion as "*scholarship*" involving research process for maintaining a high quality of education and teaching (Hult 2001). Both definitions of what a good teaching practice engender the idea that this concept is identical to all disciplines. However, Tobin (2012) points out that:

"*Being an effective science teacher entails much more than changing one or two variables and maintaining high expectations for the achievement of youth. Instead, effective teaching is complex, necessitating that teachers enact successful chains of interactions, not just for one person, or even one person at a time, but for a social network, producing and sustaining learning environments built upon fluent transactions that facilitate collective and individual outcomes. Teaching science is collective, and it is important that all participants, teachers and students, have a sense of the game that affords forms of participation that are timely, appropriate, and anticipatory*." (p. 3).

Disciplinary culture is composed of several elements. From physicists' idolisation of 'reputation', who may identify, for example, with Einstein (Clark 1980) to the amassing of artefacts that anthropologists might prefer, the signs of belonging to a disciplinary culture are numerous and diverse. For his part, Leary (1992) perceives the discipline to be like a family that provides a metaphor and models rather than a coherent field. One sociological perspective explained by Guyot and Bonami (2000), the culturalist approach, believes that each scientific discipline is characterised by, in addition to its scientific field within its epistemological aspect, a community of academics and scientists that lends it a sociological dimension. Then, the specific relations between the scientific field and the community of academics and scientists, influenced simultaneously by elements that are internal and external to the scientific and academic field, demarcate the scientific discipline. The key elements of a disciplinary culture hinge on six points (Prediger 2004, p.14). Knowledge transmission (including accepted notions and theorems, ways of reasoning and presenting arguments, and also common meanings and references), 2). Language, with its notions and meanings, 3). How one works with its techniques and tools, 4). Norms, values and beliefs (including issues deemed to be of importance, intentions, the definition of aims, appraisals of the importance and beauty of the results, and scientific theories and rules for justifying, defining and creating new notions, 5). Social organisation (game roles and rules), and finally 6). Initiation and exclusion mechanisms.

Grouped in this way, by disciplinary culture, each 'academic tribe' (Becher 1989) defines its own identity and vehemently defends its intellectual field of study with the aim of keeping any intruder at bay. Entering the lair of an academic discipline entails loyalty towards the group and adhering to its norms. The disciplines behave more like tribes than communities. Territoriality prevails over rational decision making and competition restricts access across disciplinary borders. Becher (Ibid.) notes, furthermore, that specialisation leads to greater fragmentation as specialists focus on their own sub-field and ignore links to other sub-fields. Thus, a discipline's culture proves to be an unavoidable concept in intellectual work which, nevertheless, in certain cases, is liable to hamper research and impede interdisciplinary collaboration (Coast et al. 2007). That is not all. Resistance to all pioneering ideas remain intrinsic among academic communities and engenders the phenomenon of 'organised scepticism' (Merton 1973). Nevertheless, science teaching research has demonstrated that "*conceptual change informed teaching usually is superior to more traditional means of teaching. Hence, conceptual change may still be a powerful frame for improving science teaching and learning*" (Duit and Treagust 2003).

Consequently, if differences exist between the disciplines as regards the way in which SoTL is perceived and applied (McKinney 2013), what about pedagogical innovation? Are they also perceived and applied differently from one discipline to another? The existence of disciplinary culture within universities is a phenomenon that influences the research about the pedagogical innovation introduced by professors in a university that is strongly committed to research. It appears, therefore, relevant to use the notion of disciplinary culture as an analytical category in order to take account of the fact that professors operate within sub-environments and are influenced by this phenomenon. Still, the discipline is a positive factor for pedagogical innovation whilst students' intellectual development remains a priority (Donald 2002). Consequently, it seems legitimate to enquire as to the effect of disciplinary culture on the pedagogical innovation used by professors and leads me to the following research questions: "*Is pedagogical innovation specific to a particular disciplinary culture? Or, does a specific type or several types of pedagogical innovation exist that are common to all disciplines?*"

2. University Disciplinary Culture

Defining the concept of disciplines within higher education proves to be extremely arduous, however, a number of researchers have tackled this task from different angles, as for example Donald (1995) when exploring the nature of discipline explains that "*the method by which knowledge is arrived at in a discipline, the process of knowledge validation, and the truth criteria employed in that process are essential to the definition of a discipline*" (Donald 1995, p. 6).

Traditionally in teaching, a discipline refers to a specific branch of knowledge and views itself through a structural framework underlining the way in which the key elements of the organisation of the higher education system express themselves (Becher and Kogan 1980 and Clark 1983). Fischer et al.'s (2001) interpretation of disciplinary culture includes: *"all the explicit knowledge and implicit aspects that pervade a discipline and that influence the production of new knowledge and communication about existing knowledge"* (Prediger 2004, p.14). It is a question of semiotic where symbols such as words serve at codifying the knowledge (Postman and Wiengartner, 1971). Disciplinary semiotic can evoke in science "*words, images, symbols and actions*" (Lemke 1998, p. 4). Repko (2008) from interdisciplinary studies defines the disciplines with an interesting notion of assumptions which he adds to the phenomena of interest, epistemology, methods and theories. Klein (1990) who estimates that disciplines hold a major function claims that they akin to subject areas, tools, procedures or concepts as well as theories of established epistemic communities.

Yet, disciplinary culture can be defined through the community that it represents and refers to the value system of the members of the scientific community belonging to that discipline. In this case, the discipline is not only a specific area of scientific activity, but also a community of researchers using a unique *'disciplinary matrix'* (Kuhn 1962). Thus, the *modus operandi* is governed by the influence of certain predominant values on the academic actors' personalities. Whitley (1976 1984) explains a discipline as being an organised social group. Finally, the discipline is a disciplinary field akin to a set of knowledge with a reasonably logical taxonomy, a specialised vocabulary and an accepted theoretical body with a systematic research strategy, and reproduction and validation techniques (Dressel and Mayhew 1974).

Disciplinary culture has been the object of studies conducted from different perspectives. Firstly, Berthiaume (2009) looked at the elements comprising disciplinary culture. Thus, specific features of a discipline in university teaching are translated by the *'Model of Discipline-specific pedagogical knowledge (DPK) for university teaching'* (Berthiaume 2009) in which knowing *'how'* to teach and knowing *'what'* to teach are reconciled. Fundamental teaching knowledge (aims, knowledge and beliefs in relation to teaching), the specific features of a discipline (epistemological structure and sociocultural characteristics) and beliefs vis-à-vis the knowing, construction and assessment of knowledge are the elements that constitute this model. The links between these three different categories constitute the *'Discipline-specific pedagogical knowledge*' (Berthiaume 2009). The effect is that experimental science for example, which refers to a content driven discipline, mainly rely on teaching and learning methods such as lecture, small group teaching, problem-based learning, industrial work experience and practical work (Huges and Overton 2009). Furthermore, Abell (2008) recommends that topic-specific knowledge

(Shulman 1987) should be supplemented by discipline-specific knowledge in science teaching.

Nevertheless, Becher (1989) explains that the largest divides appear in relation to language. The discourses analysed during Bazerman's (1981) and Becher's (1987) studies demonstrate disciplines' cultural characteristics and underscore the aspects of the field of knowledge to which they belong. Furthermore, literary and professional language seems to play a key role in establishing a cultural identity (Becher 1989). To this end, bioscience students are also compelled to grasp the "*mode and ground-rules for communicating within the subject and the challenges which these posed*" (Hounsell and Anderson 2009, p. 74)

Secondly, Becher (1987) devised a classification of the disciplines. The classification of these different disciplinary cultures, called disciplinary taxonomy, fascinates a number of researchers and is the object of various categorisation types. For example, the taxonomy of educational aims in the cognitive field (Bloom 1956) suggests three knowledge levels that are: specific facts and concepts, approaches and methods for processing the specific knowledge, and general principles. This includes comprehension, application, analysis, and synthesis followed by evaluation. Scheffler (1965) classifies the disciplinary cultures based on their purpose (rational, empirical or pragmatic). Hirst (1974) offers a concept of knowledge and curriculum for understanding the differences between disciplines. He highlights four levels of disciplinary epistemological analysis, with each constructed in relation to the previous one. He also separates the theoretical aspect from the practical aspect by introducing the *concept,* understood as a unit of thought or an element of knowledge that allows us to organise the experience, a *logical structure*, such as the organisation of data or concepts showing the relationships between the constituent parts (a diagram), *truth criteria*, which are the norms according to which knowledge is validated and *enquiry methods and modes* that differentiate the knowledge genre through the thought processes and operations used to describe them. Adler (1982) groups the disciplines by preferred skill types resulting in the *Communication* group comprising language, literature and fine arts, the *Measurement* group encompassing mathematics and science and the *Critical judgment* group covering the social sciences.

Biglan (1973) elaborated a discipline characterisation based on empirical research. He created a multidimensional scaling process using three dimensions and highlighted differences in the extent to which a paradigm exists in a discipline. Biglan (1973) distinguishes the disciplines according to whether they are Hard, logically structured sciences that use theoretical models and frameworks and have a recognised methodology (Physics), versus Soft, humanities that do not entail any restriction to the phenomena field with more idiosyncratic content and method, and justifiable complexity (Literature). He also employs the dimension of the degree of concern with application, which he defines as Pure for the sciences that are fundamentally self-regulating (Physics), versus Applied for the sciences that are open to the complexity of the environment and eclecticism (Engineering, Education). Finally, he separates the biological and social disciplines from those that are inanimate, Life versus Non-Life.

Later, Becher (1989) transformed his predecessor's (Biglan 1973) discipline characterisation retaining only the first two dimensions: *'Hard'* versus *'Soft'* and *'Pure'* versus *'Applied'*, which leads to four discipline types (Pure Sciences – Humanities and Pure Social Sciences - Applied Social Sciences - Applied Technologies). This taxonomy is retained for the purpose of this study because it is akin to the classification of the faculties of the university where data have been collected. However, Newmann, Parry and Becher (2002) highlight a curricular difference between the Pure Science/Applied Technology disciplines which are linear and the Applied Social Sciences/Humanities which more closely resemble a spiral. It also appears that Pure Science/Applied Technology professors spend less time preparing their lessons than those from the Applied Social Sciences/Humanities.

On their side, Becher and Trowler's (2001) research work also reveals knowledge-related differences between the discipline groups. The characteristics that distinguish the four groups of Becher's (1989) categorisation in terms of knowledge are: the object of enquiry, the nature of knowledge growth, the relationship between the researcher and the knowledge, the enquiry procedures, the moderation of truth claims, and the research results. For example, in the Hard-Pure sciences, the objects of enquiry are universal quantities and simplification, knowledge growth is cumulative, the relationship between the researcher and the knowledge is impersonal and without value judgement, the enquiry procedure has clear criteria for verifying knowledge and obsolescence, truth claims are moderated by consensus on the important questions at issue, now and in the future, and the research results provide discovery and explanation. As for the Soft-Pure sciences, the objects of enquiry are details, qualities and complications, knowledge growth is iterative, the relationship between the researcher and the knowledge is personal, the enquiry procedure consists of a difference of opinion over the criteria for verifying knowledge and obsolescence, the scope of truth claims is the lack of consensus on the main issue under consideration and the research results in understanding and interpretation. For the Hard-Applied sciences, the research objects are concerned with mastering the physical environment, knowledge growth is teleological and pragmatic (know-how through hard knowledge), the relationship between the researcher and the knowledge is applied using heuristic approaches, the enquiry procedure employs both qualitative and quantitative methods simultaneously, the moderation of truth claims is teleological and functional, and the research results in products and techniques. In the Soft-Applied sciences, enquiry objects focus on improving semi-professional practice, the progression of knowledge is functional and useful (know-how through soft knowledge), the enquiry procedure is largely based on case studies and jurisprudence, and the research results in protocols and procedures.

Thirdly, for her part, Donald (2002) studied the pedagogical capacity of each discipline. This completely different study perspective is interested in each discipline's pedagogical capacity and seeks to understand what students experience when they learn to think within a discipline and enquires as to a discipline's pedagogical capacity to attain student intellectual development objectives (Donald 2002). An analysis was carried out across the disciplines of physics, engineering, chemistry, biology, law, psychology, education and English literature into the nature of their concepts, logical structure, and the necessary criteria and processes, in order to validate knowledge and the investigative methods for acquiring this. A comparison of learning from the natural sciences disciplines against that from the social sciences and humanities is presented. Even more interestingly, here teaching methods are mentioned and can discern several types of pedagogical innovation used: for example, group work and computer usage in law; and classroom discussion, cooperative learning and project-based learning in educational sciences (Donald 2002, p. 273). It also appears from her work that discipline is a conducive factor to pedagogical innovation when the intellectual development of students remains a priority. As an example, biosciences ways of thinking have predilection for two main activities which are interactions of students with the literature and experimental data and the students attempt to communicate what they have been learning (McCune and Hounsell 2005).

Lastly, Barnett and Coate (2005) highlighted the proportional difference, by discipline, of the three elements comprising a curriculum. Another very interesting concept of disciplinary culture can be found in their *'General Schema'*. They believe that a curriculum contains three elements: *'Knowing' 'Acting'* and *'Being'*. Barnett and Coate's (Ibid.) work allows us to observe differences in the proportions of these three elements between the various disciplines. For example, in the arts and humanities the knowing element is the largest and that of acting is a little smaller than that of being. However, in science and technology, knowing's share is identical to the arts and humanities, but conversely that of acting is larger than that of being.

Research on disciplinary culture has adopted a wide range of perspectives, enabling us to find ways to classify disciplines, to probe what they are made of, to evaluate how they impact on curriculum elements and determine what a discipline engenders in terms of pedagogical capacity, asserting the diversity of impacts of disciplinary culture onto the university culture. Yet, disciplinary concept prevents innovation as it sets boundaries for what is done and how things should be done and breaking the rules, the tradition, becomes then difficult (Kreber, 2009).

This makes me think that engaging innovations in teaching may reveal more tricky within strongly established disciplinary culture such as science for example. Just like a change of values to reach science education responsibility is expected, barriers and resistance from science professors (Hodson 2003) need to be addressed.

3. Methodology

Qualitative research proves to be the most appropriate for this research as it is characterised by an approach that aims to describe and analyse human culture and behaviour and allows us to describe and interpret meanings and tendencies within a particular culture or social group (McMillan 2004). It also allows adjustments during the progress of the research and the construction of the object of the survey itself can progressively thrive. Moreover, qualitative research was employed for its ability to allow the researcher to understand the internal point of view (Pires, 1997)

Data collection took place in Canada among assistant, associate or full professors at the Université de Montréal, a Canadian, francophone institution that is strongly committed to research. The university is seeing the birth of research centres bringing together researchers from various disciplinary cultures, contrary to tradition, which groups researchers according to their disciplinary affiliation. Moreover, Becher and Trowler's (2001) studies find Becher's (1989) categorisation problematic in the light of the changes in higher education relating to the spread of interdisciplinarity. Despite this, it seems appropriate, to us, to approach this research from a disciplinary perspective, following the faculty division existing at the Université de Montréal, and more specifically the categorisation of four discipline types defined by Becher (Ibid.).

I conducted individual semi-structured interviews and one group interview with five of the same professors. Individual interview schedule was, with their granting authorisation, inspired from the one of Hannan and Silver (2000). It revolves around ten points: 1). The clarification of the interview (who I am, going through the ethics protocol and their innovations, what and when). 2). The previous history relevant to innovation (when he/she became innovator, how did it happen, in what context, alone or in collaboration). 3). Why innovate? (Intention, purposes? Pressures, inducements or opportunities? Theory?) 4). The innovation proceed (Its extend, support - departmental, institutional or external, the implementation process, the responses of colleagues, students and the institution, its evaluation). 5). The life history of the innovation (Continuation, adaptation, extension / adoption). 6). The interest in the innovation (Publications, other outcomes). 7). The reflection on the process (adequacy of the support, opposition and obstacles, roles of committees and colleagues, did it survive, died, become embedded, change). 8). The personal outcomes as innovator (Is there any? Positive and negative outcomes). 9). Lessons (implications for innovation / innovators, implication for institutional organization / policy, implication for funding bodies, quality assurance). 10). Thanks.

The criteria used to select participants entailed being an assistant, associate or full professor and recipient of an excellence in teaching award at least once over the past nine years. Forty nine professors matching the criteria have been solicited and thirty seven have agreed to participate in this research. The first two persons are considered as test-interviews and are excluded from the results. I have reached empirical saturation (Glaser and Strauss 1967, p. 67) on the thirty second interview (excluding the test-interviews). The sample consists of 32 assistant (16%), associate (44%) or full (41%) professors with 44 % of men and 56 % of women. Only 44% is committed to a management responsibility. Fourteen (14) professors are from faculties of veterinary medicine, medicine, nursing, pharmacy or architecture, six (6) are from education or law, another six (6) from sciences and finally, six (6) are from social and psychology sciences. According to Becher's (1989) classification, fourteen (14) professors came from Hard-Applied sciences, six (6) from Soft-Applied sciences, six (6) from Hard-Pure sciences and six (6) from Soft-Pure sciences. 44% of participants is men and 56% is women. 44% has management responsibilities. The complete interview transcript amounted to four hundred and fifty (450) pages of verbatim.

The grounded theory was chosen as data analysis method (Paillé, 1994) which was used as an analytical process. A grounded theory, specific methodology developed by Glaser and Strauss (1967) for the purpose of building theory from data, is developed and validated simultaneously, through a method of constant comparison between the reality observed and the emerging analysis (Ibid). Thus, the theory ensures that the result is, as it should be, "*firmly grounded in empirical data*" (Paillé, 1994, p. 150).

This iterative process of progressively theorising a phenomenon involves six fundamental steps: coding, categorisation, connection, integration, modelling and theorisation (Ibid). Open coding, categorising the elements of the interviewed professors' discourses, revealed five hundred and fifty-seven (557) sub-themes, the substantive categories and axial coding. It also sheds to light fifty (50) formal categories. The main emergent themes describe pedagogical innovation, its process and types, explain the reaction of the peers, the students and the institution to pedagogical innovation and relate to the teaching profession and the University of today.

As calculated by QDA Miner software, the 70% required to guarantee coding validity was achieved or exceeded for 25% of the material with an overlap criterion of 75% and Krippendorff's Alpha statistical method (Krippendorff, 2004) to correct the chance factor. Selective coding followed Paillé's (1994) fundamental stages of integration, modelling and theorisation. This is the ordered reconstruction of the discourse that highlighted different forms for reconstructing the experience of pedagogical innovation, according to the interviewed professors. All the remarks were delimited, then the dynamic of the phenomenon under study was reproduced and theorised through meticulous reconstruction. This third phase was carried out against a backdrop of theoretical sampling and continuous comparison throughout all the stages. This process results in an empirically grounded theory of a phenomenon thus validated by the facts. These theorisation operations were performed manually.

4. Pedagogical Innovation Types from the Perspective of Disciplinary Culture

From the data in the interviewed professors' discourses fifty-one (51) sub-themes or substantive categories, related to the types of pedagogical innovation used by the interviewed professors at the Université de Montréal, were first extracted (Walder, 2014). A new pedagogical innovation taxonomy, emerged from their discourses (Ibid.). The seven categories hinge on pedagogical innovation related to: 1) the professor's concept of teaching, 2) the pedagogical approaches adopted, 3) tools, 4) support schemes, 5) interdisciplinarity, 6) interculturality and 7) professionalisation (Ibid.) and are described and analysed in-depth in my other article named "*Pedagogical innovation: between social reality and technology*" (Ibid.).

Here, will be presented the analysis of the seven (7) pedagogical innovation categories according to Becher's (1989) disciplinary culture categorisation which was chosen as it corresponds to the segmentation of the faculties within the Université de Montréal. In order to clarify the analysis below, examples of the disciplines will be provided according to the categorisation. The medical or nursing science faculties fall under the Hard-Applied sciences. The Hard-Pure sciences include physics, biology and also chemistry. The Soft-Pure sciences encompass psychology, anthropology and philosophy. Finally, the Soft-Applied sciences can be represented by the Faculties of Education or Law.

The results of pedagogical innovation categories according to Becher (1989) categorisation are visually represented in Table 1. *Instances and Frequency of pedagogical innovation categories according to Becher (1989) categorisation* by instance (one instance is one interviewed professor participating in our research. Here, this column shows the number of instances –professors – who have one or more segments coded to the sub-theme) and frequency, meaning the number of segments coded as relating to the sub-theme related to the types of pedagogical innovation used by the interviewed professors at the Université de Montréal.

4.1. Pedagogical Innovation Related to the Concept of Teaching

Pedagogical innovation related to a professor's concept of teaching includes professors' desire to take students' prior knowledge as a starting point, to use surprise, understood like an electric shock, to engage students' various senses, to require compulsory class attendance and to promote the idea of learning to learn for in-depth learning. Table 2. *Presence of pedagogical innovation related to professors' concept of teaching, according to Becher (1989)* illustrates the presence of the different types of pedagogical innovation related to the concept of teaching, according to the interviewed professors.

Table 1. *Instances and Frequency of pedagogical innovation categories according to Becher (1989) categorisation*

Pedagogical innovation related to	Instances				Frequency			
	Soft-applied	Hard-applied	Soft-pure	Hard-pure	Soft-applied	Hard-applied	Soft-pure	Hard-pure
Learning to learn			1	1			2	1
Continuous class attendance			1	1			2	1
Taking the students as a starting point	2	1	1	2	4	1	3	2
Surprise	1		2	2	1		4	2
Teacher caricature				1				1
Renouveller le message toutes les 10-15 minutes				1				2
R-A Research approach		1				1		
Skill-based approach	1	8			1	18		
Problem-based approach	3	6	1	2	9	8	1	2
Programme-based approach	1	1			4	1		
Project-based approach		2	1	2		3	3	2
Virtual project-based approach		1				1		
LSA approach		1				1		
Reflexive approach	2	3	1		3	4	2	
Web databases	1	3			1	6		
Note-taking exercise books	1				1			
Video clips		2	2	4		2	3	5
Conceptual maps	1	3		1	1	8		1
Online lessons	3	4	1		4	12	2	
Slides		1	1	2		1	4	2
Software (IT)		2		2		2		3
Quebec pedagogical manual	1		1		1		4	
3D modelling		1				1		
PowerPoint			2	1			3	2
StudiuM (University learning portal)		2				4		
Clickers		4	2			9	3	
Clinical case studies			1				2	
Wikis		1				2		
Cooperation	2	8	5	4	7	17	15	6
Debates				1				2
Student supervision	2			1	3			1
Peer assessment				1				1
Discussion forum		2				2		
Pedagogical leader		1				1		
Group meals			2				2	
Individual or group meeting		3	1	1		4	2	1
Feedback	1		1		5		4	
Professor support	1				2			
Former student mentoring			1				1	
Videoconferencing		2				3		
Interdisciplinarity	3	6	1		5	14	1	
Mixed programmes (UdeM and another campus)	1	1			5	1		
Scientific articles	1	1		1	2	1		2
Scientific symposia	1	1	1	2	2	1	1	2
Doctorate prof. integration classes	1				1			
Creating a laboratory		1				1		
Evoking the reality of the world of work	2	8	2	4	4	16	5	11
Role plays		1	1			1	2	
Patient as care partner		1				3		
Pratice		1	1			1	2	
Simulation	1	3	1		2	3	2	

Table 2. *Presence of pedagogical innovation related to professors' concept of teaching, according to Becher (1989)*

Pedagogical innovation related to the professors' concept of teaching	**Sciences**			
	Soft-Applied	**Hard-Applied**	**Soft-Pure**	**Hard-Pure**
Learning to learn			X	X
Continuous class attendance			X	X
Taking the students as a starting point	X	X	X	X
Surprise	X		X	X
Teacher caricature				X
Reiterating the message every 10 to 15 minutes				X

Let's begin with the sole similarity that exists between the four different disciplinary cultures as regards pedagogical innovation related to professors' concept of teaching. This attests to a common will among the professors to build their teaching upon students' prior knowledge. Furthermore, pedagogical innovation seeking to surprise students is evoked by the Soft-Applied, Soft-Pure and Hard-Pure sciences, but is not mentioned in the Hard-Applied sciences.

If Continuous class attendance and learning to learn are both absent from the Hard-Applied and Soft-Applied sciences, but are present in the Soft-Pure and Hard-Pure sciences.

Hard-Pure sciences employ all the pedagogical innovation types mentioned by the interviewed professors related to teaching concepts. The Soft-Pure science participants listed four types of innovation whilst those from the Soft-Applied sciences only listed two and the Hard-Applied science professors only mentioned one. Moreover, the Soft-Pure and Hard-Pure sciences have quite similar profiles and share almost the same pedagogical innovation types in terms of teaching concept, whilst the Hard-Applied sciences category proves to be the most distant. In conclusion, pedagogical innovation related to professors' concept of teaching is more important for the Pure sciences than for the Applied sciences.

4.2. Pedagogical Innovation Related to Pedagogical Approach

Pedagogical innovation characterised by the pedagogical approach, adopted by participants, includes the research-action research approach, the skill-based approach, the problem-based approach, the programme-based approach, the project-based approach, the learning simulation in assessment (LSA) approach, the reflexive approach and finally the virtual project-based approach. Table 3. *Presence of pedagogical innovation related to pedagogical approach, according to Becher (1989) categorisation* illustrates the presence of the different types of pedagogical innovation related to pedagogical approach, according to the interviewed professors.

Table 3. *Presence of pedagogical innovation related to pedagogical approach, according to Becher (1989) categorisation*

Pedagogical innovation related to pedagogical approach	**Sciences**			
	Soft-Applied	**Hard-Applied**	**Soft-Pure**	**Hard-Pure**
R-A research approach		X		
Skill-based approach	X	X		
Problem-based approach	X	X	X	X
Programme-based approach	X	X		
Project-based approach		X	X	X
Virtual project-based approach		X		
LSA approach		X		
Reflexive approach	X	X	X	

Firstly, the problem-based approach is common to all four categories. Furthermore, the research-action approach, the virtual project-based approach and the LSA approach were only indicated by the Hard-Applied science category participants. The project-based approach seems to have followers among Hard-Applied, Soft-Pure and Hard-Pure science professors and the reflexive approach was evoked by respondents from the Soft-Applied, Hard-Applied and Soft-Pure sciences. Finally, the skill-based approach and the programme-based approach were named in the Soft-Applied and Hard-Applied science categories.

I observe that no two categories obtained identical profiles. Nevertheless, the Soft-Pure and Hard-Pure science categories both seem less enthusiastic about pedagogical innovation related to pedagogical approach whilst the Hard-Applied sciences, for their part, mentioned each of the pedagogical approaches. Furthermore, the Applied sciences use more different pedagogical approaches that the Pure sciences, but above all, it is the Hard-Applied sciences that are partial to them.

4.3. Pedagogical Innovation Related to Tools

Pedagogical innovation brought about by tools includes web databases, clickers (student response systems), online lessons, video clips, conceptual maps, slides, the creation of pedagogical manuals, software (IT), three-dimensional modelling, PowerPoint presentations, university learning portals, clinical case studies, Wikis and note-taking exercise books.

Firstly, none of Becher's (1989) categories have identical profiles and that the presence of tool-related pedagogical innovation is very disparate. Thus, video clips, online classes and slides were alluded to by three of Becher's (Ibid) categories. Table 4. *Presence of pedagogical innovation related to tools, according to Becher (1989) categorisation* illustrates the presence of the different pedagogical innovation types related to tools, according to the interviewed professors.

Video clips and slides appear to be common to the Hard-Applied, Soft-Pure and Hard-Pure sciences. Online lessons were quoted by the Soft-Applied, Hard-Applied and Soft-Pure sciences. Next, the Soft-Applied and Hard-Applied sciences made reference to web databases and the Hard-Applied and Hard-Pure sciences displayed interest in conceptual maps and software (IT). The Quebec pedagogical manual is one of the tools created in the Soft-Applied and Soft-Pure sciences. For their part, clickers were talked about by the Hard-Applied and Soft-Pure sciences. PowerPoint was mentioned as a pedagogical innovation tool by the Soft-Pure and Hard-Pure sciences. 3D modelling, StudiUM and Wikis were highlighted by the Hard-Applied sciences and note-taking exercise books by the Soft-Applied sciences. Finally, clinical case studies were used by the Soft-Pure sciences.

Table 4. *Presence of pedagogical innovation related to tools, according to Becher (1989) categorisation*

Pedagogical innovation related to tools	**Sciences**			
	Soft-Applied	**Hard-Applied**	**Soft-Pure**	**Hard-Pure**
Web databases	X	X		
Note-taking exercise books	X			
Video clips		X	X	X
Conceptual maps		X		X
Online lessons	X	X	X	
Slides		X	X	X
Software (IT)		X		X
Quebec pedagogical manual	X		X	
3D modelling		X		
PowerPoint			X	X
StudiUM (university learning portal)		X		
Clickers		X	X	
Clinical case studies			X	
Wikis		X		

Table 5. *Instances of pedagogical innovation related to tools according to Becher (1989) categorisation*

Pedagogical innovation related to tools	**Instances**			
	Soft-applied	**Hard-applied**	**Soft-pure**	**Hard-pure**
Web databases	1	3		
Note-taking exercise books	1			
Video clips		2	2	4
Conceptual maps	1	3		1
Online lessons	3	4	1	
Slides		1	1	2
Software (IT)		2		2
Quebec pedagogical manual	1		1	
3D modelling		1		
PowerPoint			2	1
StudiuM (University learning portal)		2		
Clickers		4	2	
Clinical case studies			1	
Wikis		1		

Data analysis, of the results illustrated in Table 5. *Instances of pedagogical innovation related to tools according to Becher (1989) categorisation* below, by category allows me to put forward, represented visually in Figure 1. Categorisation of aims achieved using tools by discipline, a suggestion of the aims achieved by the pedagogical innovation tools used at the Université de Montréal by the interviewed professors.

More specifically, the Hard-Pure science participants seem to use the tools for the purpose of offering students visual support (video clips, conceptual maps, slides, software (IT) and PowerPoint). The Soft-Pure science professors appear to be interested in presenting information (video clips, slides, Quebec pedagogical manuals, clinical case studies and PowerPoint), accessibility (online lessons) and assessing student learning (clickers). Furthermore, the Soft-Applied science respondents seem to employ the tools in order to make information available to students (web databases, note-taking exercise books, online lessons and the Quebec pedagogical manuals) and offer a visual support (conceptual maps).

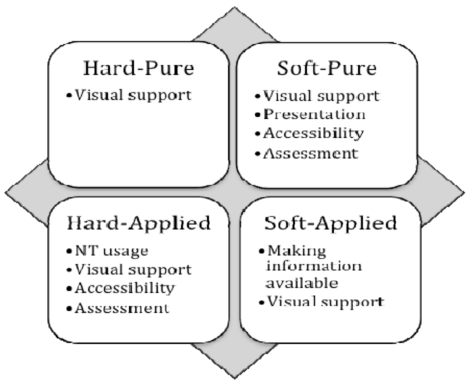

Figure 1. *Instances of pedagogical innovation related to tools according to Becher (1989) categorisation*

The Hard-Applied science teachers seem to focus on using new technologies (web databases, video clips, conceptual maps, online lessons, slides, 3D modelling, software (IT), StudiUM, clickers and Wikis). It is important to note that PowerPoint presentations no longer appear to be deemed innovative for this category.

4.4. Pedagogical innovation related to support schemes

Pedagogical innovation related to support schemes includes the support provided personally to the student by a professor or for a specific need, student supervision from a more formal perspective, feedback, professor-student and inter-peer interaction during individual or group meetings or at group meals, the organisation of discussion forums and videoconferencing to encourage and promote cooperation in all its forms, the 'Pedagogical Leader', peer assessment and former student mentoring. Table 6. *Presence of pedagogical innovation related to support schemes, according to Becher (1989) categorisation* illustrates the presence of the different pedagogical innovation types related to support schemes, according to the interviewed professors.

It is observed that the cooperation as a pedagogical innovation related to support schemes is common to all of Becher's (1989) categories. Individual or group meetings are also shared by the Hard-Applied, Soft-Pure and Hard-Pure participants. I point out that former student mentoring and group meetings including a meal were stipulated by the Soft-Pure science respondents. Student supervision was mentioned by Soft-Applied and Hard-Pure science respondents and feedback by Soft-Applied and Soft-Pure science professors. For their part, the Hard-Applied science teachers indicated that they use discussion forums, pedagogical leaders and videoconferencing. The Hard-Pure science participants evoked debates and peer assessment, and those from the Soft-Applied sciences used professor support.

Table 6. *Presence of pedagogical innovation related to support schemes, according to Becher (1989) categorisation*

Pedagogical innovation related to support schemes	Sciences			
	Soft-Applied	Hard-Applied	Soft-Pure	Hard-Pure
Cooperation	X	X	X	X
Debates				X
Student supervision	X			X
Peer assessment				X
Discussion forums		X		
Pedagogical leader		X		
Group meals			X	
Individual or group meeting		X	X	X
Feedback	X		X	
Professor support	X			
Former student mentoring			X	
Videoconferencing		X		

4.5. Pedagogical Innovation Related to Interdisciplinarity

Pedagogical innovation related to interdisciplinarity encompasses the general principle of the professor opening up their class to speakers from other disciplines with the aim of demonstrating the global nature of the links between the disciplines, which may even extend to a more conceptual dimension. The pedagogical innovation related to interdisciplinarity, illustrated in Table 7. *Presence of pedagogical innovation related to interdisciplinarity according to Becher (1989) categorisation,* appears to be common to three of Becher's (1989) disciplinary culture categories: the Soft-Applied sciences, the Hard-Applied sciences and the Soft-Pure sciences.

Table 7. *Presence of pedagogical innovation related to interdisciplinarity, according to Becher (1989) categorisation*

Pedagogical innovation related to interdisciplinarity	Sciences			
	Soft-Applied	Hard-Applied	Soft-Pure	Hard-Pure
Interdisciplinarity	X	X	X	

4.6. Pedagogical Innovation Related to Interculturality

Pedagogical innovation related to interculturality takes place through mixed programmes, remotely and in situ in the country of origin and at the Université de Montréal, offered in the students' mother tongue.

As Table 8. *Presence of pedagogical innovation related to interculturality, according to Becher (1989) categorisation* illustrates, interculturality only appears to be common to two of Becher's (Ibid) disciplinary culture categories: the Soft-Applied and the Hard-Applied sciences.

Table 8. *Presence of pedagogical innovation related to interculturality, according to Becher (1989) categorisation*

Pedagogical innovation related to interculturality	Sciences			
	Soft-Applied	Hard-Applied	Soft-Pure	Hard-Pure
Mixed programmes	X	X		

4.7. Pedagogical Innovation Related to Professionalisation

Pedagogical innovation aimed at professionalisation hinges on the idea of integrating the reality of the world of work into teaching itself or immersing students in real situations from their future profession. Thus, while some professors organise simulations and role plays to prepare students for their practical future, others project them into real situations, such as an actual laboratory, publishing scientific articles in a journal, and active participation in, or organising, symposia.

A more global vision demonstrates an institutional interest in professionalising pedagogical innovation reflected in designing professional integration classes aimed at doctoral students and post-doctoral interns. Table 9. *Presence of* *pedagogical innovation related to professionalisation, according to Becher (1989) categorisation* illustrates the presence of the different pedagogical innovation types related to professionalisation.

Here let's highlight that scientific symposia and evoking the reality of the world of work are common to all of Becher's (1989) categories. Next come scientific articles and simulation, which are both present in the Soft-Applied and Hard-Applied sciences and in Hard-Pure for the former and Soft-Pure for the latter. Role plays and practice were mentioned by professors from the Hard-Applied and Soft-Pure sciences. Creating a laboratory and the patient as care partner fall into the Hard-Applied sciences category, while the doctoral students' professional integration courses were initiated by Soft-Applied science respondents.

Table 9. *Presence of pedagogical innovation related to professionalisation according to Becher's (1989) categorisation*

Pedagogical innovation related to professionalisation	Sciences			
	Soft-Applied	Hard-Applied	Soft-Pure	Hard-Pure
Scientific articles	X	X		X
Scientific symposia	X	X	X	X
Doctorate prof. integration classes	X			
Creating a laboratory		X		
Evoking the reality of the world of work	X	X	X	X
Role plays		X	X	
Patient as care partner		X		
Practice		X	X	
Simulation	X	X	X	

5. Identifying Pedagogical Innovation Types Common to Several Disciplines

The interviewed professors expressed and described the existence of numerous pedagogical innovation types emanating from highly varied fields. This underscores the ingenuity and creativity of the teaching body. I realised that the concept of pedagogical innovation varies somewhat from one disciplinary culture to another. In other words, the professors have a fairly similar overall concept, with some diverging tendencies. This said, now let's proceed to highlight the pedagogical innovation types that are common to several disciplines.

However, due to the exploratory nature of this study, I do not claim to be able to make statements about the pedagogical innovation types that are absent or to confirm if they are used or not by professors at the Université de Montréal. Nevertheless, I am in a position to identify certain pedagogical innovation types that appear to be common to all disciplines or specific to only two or three of them. In order to guide the reader in this analysis their presence or absence is illustrated in the Table 10. *List of pedagogical innovation types common to more than one of Becher's (1989) categories.*

Here is observed a total of twenty-nine (29) pedagogical innovation types that are common to two, three or four of Becher's (1989) categories. More specifically, the results of the analysis permit me to list five (5) pedagogical innovation types that are common to Becher's (Ibid.) four disciplinary cultures. These are, firstly, pedagogical innovation related to professors' concept of teaching: taking the students as a starting point. Next there is a pedagogical approach-related pedagogical innovation: the problem-based approach. In third place I can identify pedagogical innovation related to a support scheme: cooperation, followed by, in fourth and fifth places, professionalisation-related innovation: scientific symposia and evoking the reality of the world of work. Consequently, none of the pedagogical innovation types related to tools, interdisciplinarity or interculturality appears in all four of Becher's (Ibid.) disciplinary culture categories.

Consequently, the pedagogical innovation types that are common to three disciplines are split between, on the one hand, a group comprised of the Hard-Applied, Soft-Pure and Hard-Pure sciences with the project-based approach, video clips, slides, and individual or group meetings and on the other hand, a unit formed of the Soft-Applied, Hard-Applied and Soft-Pure sciences with the reflexive approach, online lessons, interdisciplinarity and simulation. Finally, surprise is common to the Soft-Applied, Soft-Pure and Hard-Pure sciences and Scientific articles to the Soft-Applied, Hard-Applied and Hard-Pure sciences.

Table 10. *List of pedagogical innovation types common to more than one of Becher's (1989) categories*

Pedagogical innovation related to	Description	Sciences			
		Soft-Applied	Hard-Applied	Soft-Pure	Hard-Pure
COMMON TO 4 CATEGORIES					
The concept of teaching	Taking the student as a starting point	X	X	X	X
Pedagogical approaches	Problem-based approach	X	X	X	X
Support schemes	Cooperation	X	X	X	X
Professionalisation	Scientific symposia	X	X	X	X
Professionalisation	Evoking the reality of the world of work	X	X	X	X
COMMON TO 3 CATEGORIES					
The concept of teaching	Surprise	X		X	X
Pedagogical approaches	Project-based approach		X	X	X
Pedagogical approaches	Reflexive approach	X	X	X	
Tools	Video clips		X	X	X
Tools	Online lessons	X	X	X	

Pedagogical innovation related to	Description	Sciences			
		Soft-Applied	Hard-Applied	Soft-Pure	Hard-Pure
Tools	Slides		X	X	X
Tools	Individual/group meeting		X	X	X
Interdisciplinarity	Interdisciplinarity	X	X	X	
Professionalisation	Scientific articles	X	X		X
Professionalisation	Simulation	X	X	X	
COMMON TO 2 CATEGORIES					
The concept of teaching	Learning to learn			X	X
The concept of teaching	Continuous class attendance			X	X
Pedagogical approaches	Skill-based approach	X	X		
Pedagogical approaches	Programme-based approach	X	X		
Tools	Web databases	X	X		
Tools	Conceptual maps		X		X
Tools	Quebec pedagogical manual	X		X	
Tools	PowerPoint			X	X
Tools	Clickers		X	X	
Support schemes	Student supervision	X			X
Support schemes	Feedback	X		X	
Interculturality	Mixed programmes	X	X		
Professionalisation	Role plays		X	X	
Professionalisation	Practice		X	X	

As regards the pedagogical innovation types common to two disciplines, firstly these are found in a group formed by the Soft-Applied and Hard-Applied sciences with the skills-based approach, the programme-based approach, web databases and mixed programmes.

Next, in a unit comprised of the Soft-Pure and Hard-Pure sciences there is learning to learn, continuous class attendance and PowerPoint. Finally, there are the grouping of Soft-Applied and Soft-Pure for the Quebec pedagogical manual and feedback. Conceptual maps are common to the Hard-Applied and Hard-Pure sciences and student supervision is present in both the Soft-Applied and Hard-Pure sciences.

The distribution of the number of recurrences, by pair, of pedagogical innovation types used at the Université de Montréal, illustrated in table 11. Number of recurrences by pair, according to Becher (1989), allows me to see that the Soft-Pure and Hard-Applied science professors interviewed in this study share the largest number of pedagogical innovation types. Conversely, the Soft-Pure and Soft-Applied science professors invest jointly the least in similar pedagogical innovation types. In other words, this means that the Hard-Applied and Soft-Pure sciences are the most similar in terms of pedagogical innovation types used, whilst the Soft-Pure and Soft-Applied sciences are the most dissimilar.

Table 11. *Number of recurrences by pair, according to Becher (1989) categorisation*

Sciences	Soft-Applied	Hard-Applied	Soft-Pure	Hard-Pure
Soft-Applied		14	7	8
Hard-Applied	14		16	11
Soft-Pure	7	16		13
Hard-Pure	8	11	13	

6. Pedagogical Innovation Tendencies by Disciplinary Culture

The results of the pedagogical innovation categories according to Becher (1989) categorisation, illustrated in Table 12. *Pedagogical innovation categories according to Becher (1989) categorisation*, allow me to portray the dominant pedagogical innovation categories, represented visually in Figure 2. *Portrait of the dominant pedagogical innovation categories, and to state each disciplinary culture's preferences*.

The Hard-Pure sciences focus on pedagogical innovation related to the tools, concept of teaching and support schemes. The Soft-Pure sciences prefer pedagogical innovation related to tools, support schemes and professionalisation. The Hard-Applied sciences use pedagogical innovation related to tools, pedagogical approaches and professionalisation.

Table 12. *Pedagogical innovation categories according to Becher (1989) categorisation*

Pedagogical innovation related to	Instances			
	Soft-applied	Hard-applied	Soft-pure	Hard-pure
The professors' concept of teaching	3	1	5	8
Pedagogical approach	7	23	3	4
Tools	7	23	10	10
Support schemes	6	16	10	8
Interdisciplinarity	3	6	1	
Interculturality	1	1		
Professionalisation	6	17	6	7

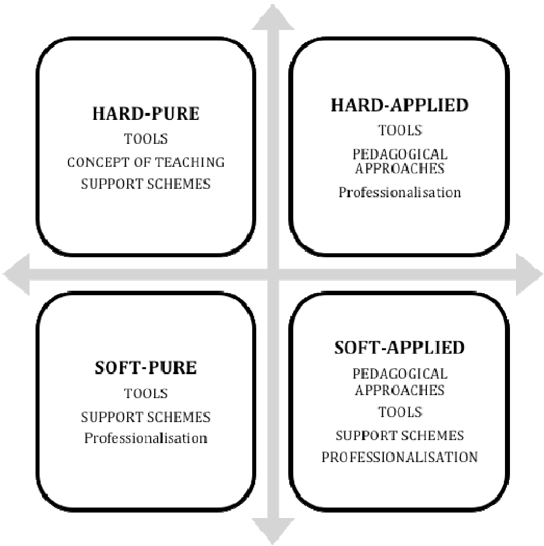

Figure 2. *Portrait of the dominant pedagogical innovation categories*

The Soft-Applied sciences favour pedagogical innovation related to pedagogical approaches, tools, support schemes and professionalisation. The greatest pedagogical innovation diversity occurs within the Soft-Applied sciences. Therefore, they also have the largest number of dominant pedagogical innovation categories with four of the seven categories instead of three. I note that tool-related pedagogical innovation is indispensable for all the disciplinary categories. Pedagogical approaches are dominant within the Hard-Applied and Soft-Applied sciences. Contrary to the other categories, the Hard-Applied sciences do not appear to make predominant use of pedagogical innovation related to support schemes. Professionalisation is only mentioned by the Hard-Pure sciences as a pedagogical innovation to which they have sporadic recourse.

7. Conceptualising Pedagogical Innovation and Practice: Between Disciplinary Reality and External Environment

Becher (1989) used two dimensional axes to develop his disciplinary culture taxonomy: Hard versus Soft and Pure versus Applied. Pedagogical innovation related to the concept of teaching demonstrates almost identical results for the Soft-Pure and Hard-Pure sciences. Furthermore, the Soft-Applied and Hard-Applied sciences, whilst they do differ, are relatively similar. Thus, this observation suggests that a professor's concept of teaching is related to disciplinary culture, as Gaff and Wilson (1971) previously indicated when they stated that cultural differences take shape in relation to lifestyles, educational values and teaching foci. The Pure versus Applied axis appears to be in action here. It is highly tempting to venture the hypothesis, with the contrast between the results of the Pure sciences versus the Applied sciences as proof, that this axis exerts an influence on the pedagogical innovation types used by the interviewed professors at the Université de Montréal. In keeping with this, pedagogical innovation related to pedagogical approaches displays analogous results with a dichotomy between the (Soft and Hard) Pure sciences and the (Soft and Hard) Applied sciences. This observation seems to confirm this hypothesis.

The other pedagogical innovation types do not display this characteristic, which remains specific to pedagogical innovation related to professors' concept of teaching, as well as that related to pedagogical approaches. I deem it crucial to point out that pedagogical innovation related to professors' concept of teaching and pedagogical innovation related to pedagogical approaches seem to be connected to the conceptual perspective of the pedagogical innovation chosen. Pedagogical innovation related to tools, support schemes, interdisciplinarity, interculturality and professionalisation seem to be linked to the application of the pedagogical innovation and imply that they are all considered to be tools. Put another way, this is about wondering: "*with the help of what will I innovate?*" Thus, it seems appropriate to hypothesise that what is connected to the conceptual idea of pedagogical innovation is subject to the influence of the Pure versus Applied axis. On the contrary, the other, more practical, pedagogical innovation categories are not subject to the impact of either of these axes. Whilst noting that conceptual maps are common to the Hard-Applied and Hard-Pure sciences I take cognisance that the Hard versus Soft sciences dimension does not appear to have a perceptible impact, except on the conceptual map pedagogical innovation type, with structuring research being the common point (Becher, 1989).

Categorically, and in order to deepen the examination of the Pure versus Applied sciences dimensional axis, I revisit the results of the number of recurrences by pair analysed in the previous section, which were Soft-Pure and Soft-Applied (16), Soft-Applied and Hard-Applied (14) and Hard-Pure and Soft-Pure (13). I observe that the first two pairs have a common denominator, the 'applied' dimension and the latter has the same dimension, Pure sciences. Thus, I can, within the boundaries imposed by this research, assert the hypothesis that the Pure versus Applied science dimension influences pedagogical innovation. By extension to this reflection, isn't it tempting to predict, given that the applied dimension appears in the two first, most frequent pairs, that the external environment appears to exert a significant influence on pedagogical innovation and to suggest that a discipline's relationship with innovation could be a decisive factor in professors' involvement in integrating pedagogical innovation into teaching?

8. Final Thoughts

This findings highlight that the pedagogical innovation tendencies for Hard-Pure sciences, including for the purpose of this study physic, biology and chemistry professors, which focus on innovation related to concept of teaching, tools and support schemes, seem less impacted by the external environment. Yet, it sheds to light that the pedagogical innovation predilection for Hard-Applied sciences such as medicine and nursing, which concentrates their innovations onto tools, pedagogical approaches and professionalisation, are much more influenced by the external environment.

The main contribution of this work to the field of science education is that Hard-Pure sciences might further investigate professionalisation as an area where they could innovate in the future. Although discipline categories have an effect on the types of pedagogical innovation proposed by professors, the use of tools is major to Hard-Pure sciences. This indicates an opening to external world of technology. However, the latter seems to only aim at visual supports from tools while these could also be employed for accessibility and assessment purposes.

In conclusion, I have the feeling that each discipline does look at what the external world has to offer and only picks up what it trusts appropriate for itself, probably because his ethos as well as its way of thinking is permeated with disciplinary culture.

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