

The use of Multidisciplinarity, Interdisciplinarity and Transdisciplinarity to develop the Critical and Scientific Spirit in the student

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Abstract—The construction of knowledge today requires a new posture of the researcher, requires a broader and holistic view, with the interaction of the various areas, both in the expansion and in the deepening in the treatment of complex studies. Thus, the objective of this work is to identify the pedagogical practices for the development of the critical scientific spirit in the student in the learning environment. With this research, it was possible to conclude that with pedagogical practices based on the practice of inter, multi and transdisciplinarity, it is possible to contribute to an autonomous society, transforming tacit knowledge into explicit knowledge to serve as a basic tool for social development, with capacity to share and incorporate new technologies and disseminate them to society to make its economic and social transformation.

Keywords—Teaching-learning innovation, Pedagogical practices, Transdisciplinarity.

I. INTRODUCTION

Research and innovation through an articulated view of knowledge requires an inter, trans and multidisciplinary approach. This way of thinking modifies Cartesian principles, from fragmentation, from reduction to objectivism, after all, the complex themes in the contemporary world demand different looks. Thus, many discoveries and innovations that are part of the contemporary world would not have occurred had it not been for the transdisciplinary way of thinking.

The study and knowledge of various disciplines make it possible to overcome the limits imposed by science itself. For Hoff et al. (2007), the new frontiers with which science comes across indicate that specific knowledge alone is not enough to understand the complexity of the studied phenomena. Nicolescu (1999) states that there is an indispensable need for bridges between the different

disciplines, which was translated by the emergence, in the middle of the twentieth century, of multidisciplinary and interdisciplinarity. For Limaverde (2012), the concepts of multidisciplinary, interdisciplinarity and transdisciplinarity are distinct and sometimes antagonistic in their proposals and methodological objectives, but still very confused.

According to Antônio (2002), transdisciplinarity is a way of knowing and knowing knowledge. A way of thinking and thinking of thought. It rejects the rigid separation of knowledges and blind specialisms. Relate what the Cartesian thought separated and the mechanics torn apart. With these considerations, it can be affirmed that the construction of knowledge today demands a new posture of the researcher, a broader and holistic view, with the interaction of the different areas of knowledge, both in the expansion and in the deepening in the treatment of complex studies. According to Hoff et al. (2007), the need to develop new paradigms and methods, essential to ensure the accuracy and reliability of the knowledge generated, will require the renunciation of already consolidated paradigms and methods in the various disciplinary fields, as well as the establishment of multidisciplinary teams. For Vieira (2008), the research of the future is inherently multidisciplinary and interdisciplinarity.

Thus, this work aims to identify pedagogical practices for the development of critical scientific spirit in the student and to stimulate the entrepreneurial spirit in the learning environment.

II. DISCIPLINARITY, MULTIDISCIPLINARITY, INTERDISCIPLINARITY, TRANSDISCIPLINARITY AND PLURIDISCIPLINARITY.

There is a constant challenge in the information and knowledge age, where new social contexts demand new

skills and various forms of social relations scare the more conservative. In this way new ways of thinking and new ways of doing and feeling make the concepts presented help in understanding the analysis of parts and analyzes of the whole, not forgetting that everything is interacting at all levels.

For Japiassu (1976), disciplinarity is the scientific and specialized exploration of a certain homogeneous domain of study. A systematic and organized set of knowledge with its own characteristics in its teaching plans, training, methods and subjects.

According to Nicolescu (1999), disciplinary research concerns at most one and the same level of reality, in most cases, fragments.

Japiassu (1976) defines multidisciplinarity as a range of disciplines proposed simultaneously, but without making appear directly to the relations that can exist between them. It is a kind of single-level, multi-purpose system; there is no cooperation between disciplines. This would be limited to a set of disciplines to be worked simultaneously, without the relations between the parties being explicit through clear and well defined pedagogical objectives.

In relation to interdisciplinarity, Japiassu (1976) defines as the general description that involves an axiomatic common to a group of related disciplines and defined in a hierarchical level immediately superior, which introduces the notion of purpose. It is a kind of two-level system and multiple objectives with coordination proceeding from a higher level. According to Maheu (2000), interdisciplinarity comes to be the result of the articulation between two or more disciplines with common pedagogical objectives, since the disciplines cannot be considered isolated islands in a lost archipelago. It is, from this perspective, the unity of knowledge that is realized in the specificity of each one of the disciplines.

For Nicolescu (1999), interdisciplinarity has a different ambition. It concerns the transfer of methods from one discipline to another. Three degrees of interdisciplinarity can be distinguished: a) a degree of application. For example, the methods of nuclear physics transferred to medicine lead to the emergence of new treatments for cancer; b) an epistemological degree. For example, the transfer of methods from formal logic to the law field produces interesting analyzes in the epistemology of law; c) a degree of generation of new disciplines. For example, the transfer of mathematical methods to the field of physics has generated mathematical physics; from particle physics to astrophysics, to quantum cosmology; those of mathematics for meteorological phenomena or those of the stock market, the theory of chaos; from computer science to art, to computer art. Interdisciplinarity goes beyond disciplines, but its purpose also remains inscribed in disciplinary research.

From the concept of Nicolescu (1999) transdisciplinarity, as the prefix "trans" refers to what is at the same time between the disciplines, across the different disciplines and beyond any discipline. Its purpose is to understand the present world, for which one of the imperatives is the unity of knowledge. Already, Caon (1998) states that transdisciplinarity is a challenge posed by the interest of a team of professionals who are united by the metaphor proposed by a situation of transdisciplinarity, in which each researcher problematizes the concepts of different fields. The devices used to solve the problem are more important than the solution of the problem. That is, several looks through practical and theoretical devices.

It can be concluded through the reflection of Menezes and Vaccari (2005) that transdisciplinarity must permeate the formation and the attitude as trainer. It corresponds to a reform of thought and not just to structural and institutional reform.

In this sense, disciplinary and transdisciplinary research is not antagonistic, but complementary. For the authors it is certain that it is not intended to break the idea of disciplinarity. It is important to maintain the structure of a discipline with its object, as a category that organizes scientific knowledge. What cannot be admitted is the isolation of the whole of a branch of knowledge. And this is what happens when certain graduate programs refuse graduates in other areas, as if appropriating that sphere of knowledge. The circulation of ideas and concepts between distinct disciplines allows the evolution of knowledge.

According to Morin (1999), it is impossible to create a unitary science of man, it is important that each discipline establishes connections so as not to reduce the most genuine notion that can be established about this man. It is about recognizing the interdisciplinarity between the sciences.

For Nicolescu (1999) cited by Santos, Fujiki and Costa (2016) the comparison of pluridisciplinarity, interdisciplinarity and transdisciplinarity is presented below:

- **Multidisciplinarity:** The same object of study or topic of research investigated simultaneously by several disciplines. It goes beyond the disciplinary paradigm without, however, overcoming it or putting it in suspense.
- **Interdisciplinarity:** Exchange of research methods from different disciplines. In spite of being beyond the disciplines and being able to generate new disciplines, it fits in the model of the disciplinary research
- **Transdisciplinarity:** It is defined as the search for what is, at the same time, between, through and beyond any discipline, representing, therefore, a break with the disciplinary paradigm, a new way of seeing the world.

Rocha and Filho (2007) affirm that transdisciplinarity is an empathic attitude of openness to the other and its knowledge, which, like Limaverde (2012), assumes transdisciplinarity with a broad concept in which the researched subject passes through the disciplines, without aiming end the specific knowledge of this same discipline or the concern to delimit what is its object of study or what is of another interrelated area. Transdisciplinarity is concerned with the continuous and uninterrupted interaction of all disciplines, at the same time and in the same place.

For Amaral (2011) it is possible to use multidisciplinary, interdisciplinarity, transdisciplinarity and pluridisciplinarity as a learning strategy.

2.1 Transdisciplinarity and innovation

The search for a new perception of the world, from a new perspective depends on the transformations that occur in the world and the processes still in transformation. They depend on the awareness of men, the complexity of the new world, and the perspective of new knowledge. This new knowledge uses various concepts, complex thoughts and various disciplines as possible search paths.

For Morin (2000), there is an increasing and more serious inadequacy between the separate, fragmented and compartmentalized knowledge between disciplines. The author affirms that increasingly polydisciplinary, transverse, multidimensional, transnational, global, and planetary realities or problems make invisible the complex sets, the interactions and feedbacks between the parts and the whole; and between the multidimensional entities and the essential problems. Hence, hyperspecialization prevents us from seeing the global as well as the essential. This shredding prevents complexity in fact, when the components constitute a whole in the existence of the interdependence of the parts, of the interactive. For Coelho (2003), there is no doubt that this is the great problem of Teaching and Research in our day: that of knowledge to be discovered, no longer isolated, as something-in-itself, but in its complex relations with the context to which it belongs.

In the quest for answers concerning the lack of unity of knowledge, the need to link the different disciplines generated the emergence of multidisciplinary, which is the study of a given discipline in the view of others, and of interdisciplinarity, where the methods adopted by a discipline. This is the vision of BasarabNicolescu, theoretical physicist of the National Center for Scientific Research of France (C.N.R.S.) and Founder and President of the International Center for Research and Transdisciplinary Studies (CIRET).

For Nicolescu (1999), the transdisciplinary culture is based on four pillars of a new type of education: a) learning to know - means having an understanding of the scientific

spirit in a clear distinction between the real and the illusory, valuing the constant inquiries and quality of the scientific procedure as well as being able to establish correlations between the different knowledge and meanings; b) learning to do - denotes flexibility in the face of the intense changes that have occurred, in the search for greater creativity in the professional field in order to structure it according to the internal potentialities and external needs; c) learning to live together - respecting the collective and norms that permeate relationships in an effective way through the validation of the inner experience of each being and the recognition of oneself in the face of the other and d) learning to be - the transpersonal dimension is valued in order to discover whether there is harmony or disharmony between individual life and social life, in constant questions about conditioning, respecting what binds the Subject and the Object.

With transdisciplinarity it is possible to include in the curriculum the different fields of knowledge, working with real world problems. For in the processes of pedagogical activities and in the face of the new paradigms of teaching and learning, science, research and technology are situated as nuclei of study in the production of knowledge.

With the new teaching methodologies, the process of transformation of education has contributed to a more interactive teaching, in which it is no longer centered in the teacher, but in a collaborative teaching, through interdisciplinary projects, where the teacher is a researcher and guiding, and the most active student with more autonomy, more reflective. In this regard, for Mohrman and Mohrman Junior (1995), innovation takes place in the face of a creative method of harnessing existing knowledge, which provides lesser elements of knowledge in the creation of new answers or skills and, with this vision, innovation and the search for changes must be inserted, also, by educational processes, in which constant demands are demanded from the teachers / researchers, who must always be situated in all contexts of society and spheres of human life since everything in the universe is related.

III. ANALYSIS OF SURVEY RESULTS

To analyze the results of the research, content analysis was used, since this type of instrument allows multiple applications and is an important element of social research. Amado (2000) states that content analysis allows a rigorous and objective representation of message content through a varied range of communications, translating the world's subjective views. According to Bardin (2002), content analysis is a set of communication analysis techniques that uses systematic procedures and objectives to describe message content. Thus, a structured questionnaire was developed with clear and objective

questions to guarantee the uniformity of the interviewees' understanding. The data were collected through the answers of the questionnaire sent by e-mail to the researchers, which belong to the database of the CNPq - Directory of the Brazilian Research Group. The questions asked were: What have you done to develop the critical scientific spirit in the student? What have you done to stimulate the entrepreneurial spirit in the learning environment?

Below are related some teacher attitudes raised in the answers answered, already grouped, according to Chimendes (2011):

- Encouraged the student to always ask himself why and for what he is developing such research, encourage reading and research a lot and not always agree with what is written in papers, comparing and always asking, to change for the better, because what the Science says as yes today, it may not be tomorrow;
- A lot of reading by establishing parallels, analysis of similarities and differences between the various streams of thought or various ways of solving a problem; applying interdisciplinarity;
- Placing it in the face of a real problem, an intellectual problem; a transdisciplinary problem;
- I try to encourage self-reflection, avoiding the adoption of already consecrated solutions and the unconscious repetition of what already appears in textbooks; leading to classroom issues that require the learner more than memory, but reasoning. I try to take concrete situations into the classroom and make visits with the students;
- I urge students to stop thinking only as potential future business collaborators, but rather as owners of their business;
- I work my disciplines in the direction of "beyond the menu", that is, by encouraging students to look at the socioeconomic world from the point of view of these sciences; for example, criticizing the commonplace that reigns in local and national politics (I try to show that "exact sciences" have everything to do with citizenship);
- Here is the true role of the university professor! It is not only the scientific critical spirit of the student, but the critical spirit in general. The teacher must free the student's mind;
- For my part, I talk about everything in class, making "trips" that go beyond programmatic content;
- There is always a bridge between the "trip" and the program content, and always making the student leave the classroom different from what has entered, both in the programmatic content and in some extra aspect; Encouraging interdisciplinarity, collaborative work;

- Study of cases, critical analysis of selected texts, minidebates with constructive suggestions, research on various topics and the formation of technical and / or scientific articles.

For Chimendes (2011), knowledge, science, technology and technique are important inputs for production, in this new phase of capitalism, where knowledge is an important factor in competitiveness. For Silva Júnior (2002), the university has a fundamental role in the formation of knowledge and human resources, the challenge of expanding and diversifying its action in society, in order to attend to the urgencies posed by social complexity.

For Chimendes (2011), in this context, the new order makes the university feel the importance of adopting new curricular designs, innovations of a technological nature, and instrumental knowledge. This new vision of the university needs to be based on the construction of a critical awareness of the student, and on the teachers in whom, according to Gadotti (1999), educator and learners learn together in a dynamic relationship, in which theory-oriented practice redirects this theory, in a process of constant improvement. This critical thinking leads to reflection on intellectual autonomy and with this the citizen can intervene and transform reality. It is the "knowing to think" that, according to Demo (2000), is not only related to logic but also in the non-linearity of reality and life, is knowing how to remain critical, especially self-critical, is the art of arguing and against to argue.

Research is a scientific and educational principle in which the researcher critically and creatively, through scientific methods, gathers information about a given problem always with the intention of producing, increasing knowledge or even discovering something new. For Damasceno (1999), research is a problematizing activity of reality in which the fact is related and allows interpretations, contributing to new worldviews. It is a collective construction that needs to be understood and shared, thus demonstrating commitment to social reality.

For Libâneo (1991), knowledge is a condition for intellectual and political freedom. And to build a democratic society, democracy for all, more and more people need to be involved in the creation of new knowledge. This, however, depends on the appropriation of existing knowledge.

To work with research is to work with doubt, it is to walk a path of investigation; is to recognize and apply the concepts of multi, inter, trans and pluridisciplinarity. And through these concepts and applications, develop the critical and scientific spirit in the student, stimulating entrepreneurship in the learning environment.

IV. CONCLUSION

The researcher makes the dialogue with reality, where he appropriates knowledge, develops skills and produces

knowledge. Knowledge developed can result in progress for a nation. Thus, the researcher is one who identifies, integrates and systematizes knowledge, produces and disseminates knowledge and experience, and stimulates the development of new research.

The teacher is the one who teaches classes, organizes content programs, and evaluates students. This professional must also seek new knowledge through research to fully exercise his professional practice, not only transmitting knowledge but also producing knowledge. Not only be a teacher, but a research professor. Based on the results, there are some important considerations: both universities and teachers should work with students on issues related to maintaining human values, translating into society the knowledge acquired through the practice of inter, multi, transdisciplinarity, contributing to an autonomous society, transforming tacit knowledge into explicit knowledge to serve as a basic instrument for social development, capable of sharing and incorporating new technologies and thus disseminating them to society to make its economic and social transformation.

REFERENCES

- [1] AMADO, João da Silva. A técnica de análise de conteúdo. Revista Referência n. 5, nov. 2000.
- [2] AMARAL, Ester Faria do. Multi, Pluri, Trans e Interdisciplinaridade em gráficos e esquema. Disponível em: <<https://osmurosdascola.wordpress.com/2011/07/06/multi-pluri-trans-inter-mas-o-que-e-tudo-isso/>>. Acesso em: 29 set. 2017.
- [3] ANTONIO, Severino. Educação e Transdisciplinaridade: crise e reencantamento da aprendizagem. Coleção Educação & Transdisciplinaridade. Rio de Janeiro: Editora Lucena, v. 1, 2002.
- [4] BRETAG, Ryan. Evolution of the Multidimensional Learning Space Vision. jul. 2011. Disponível em: <<http://www.ryanbretag.com/blog/2011/07/evolution-of-the-multidimensional-learning-space-vision/>>. Acesso em: 29 set. 2017.
- [5] BARDIN, Laurence. Análise de conteúdo. Trad. Luís Antero Reto e Augusto Pinheiro. Lisboa: Edições 70, 2002.
- [6] CAON, J. L. Da existência analfabética à existência alfabetizada. REVISTA DO GEEMPA, v. 6, p. 37-70. Out. 1998.
- [7] DAMASCENO, Maria N. A formação de novos pesquisadores: a investigação como uma construção coletiva a partir da relação teoria - prática. In: CALAZANS, Julieta et alii (Orgs.). Iniciação científica: construindo o pensamento crítico. São Paulo: Cortez, 1999. p. 13-55.
- [8] DEMO, Pedro. Política Social do Conhecimento e Educação. *Ensaio: avaliação de políticas públicas*. EDUC. Rio de Janeiro, v. 8, n. 26, jan./mar. 2000.
- [9] GADOTTI, Moacir. História das idéias pedagógicas. São Paulo: Ática, 1999.
- [10] HOFF, D.N. ; DEWES, H.; et al. O desafio da pesquisa e ensino interdisciplinares. REVISTA BRASILEIRA PÓS GRADUAÇÃO - R B P G. Brasília, v. 4, n. 7, jul. 2007. p. 42-65.
- [11] JAPIASSU, Hilton. Interdisciplinaridade e patologia do saber. Rio de Janeiro: Imago, 1976.
- [12] LIBÂNEO, José Carlos. A pesquisa pedagógica no trabalho docente. Conferência proferida na abertura do Curso de Especialização em Alfabetização no Centro Pedagógico de Rondonópolis da UFMT, 06 mai. 1991.
- [13] LIMAVERDE, Patrícia. Parâmetros para Práticas Educativas Transdisciplinares 1. 20 ago. 2012. Disponível em: <<https://transdisciplinaridade.wordpress.com/2012/08/20/parametros-para-praticas-educativas-transdisciplinares-1/>>. Acesso em: 24 abr. 2016.
- [14] MAHEU, Cristina d'Ávila. Interdisciplinaridade e mediação pedagógica. UNIFACS: NUPPEAD/NPP UFBA (FACED) e UNEB (Deptº de Educação I). 2000. Disponível em: <<http://nuppead.unifacs.br/artigos/Interdisciplinaridade.pdf>>. Acesso em: 02 jun. 2009.
- [15] MENEZES, J.B.; VACCARI, F.C.A.S. O saber transdisciplinar no terceiro milênio e a auto-educação do professor. PENSAR, FORTALEZA, v. 10, n. 10, fev. 2005. p. 53-56.
- [16] MOHRMAN, S. A.; MOHRMAN JUNIOR, A. M. Mudanças organizacionais e aprendizado: organizando para competir no futuro. São Paulo: Makron Books, 1995.
- [17] MORIN, Edgar. A cabeça bem-feita: Repensar a reformar o pensamento. Rio de Janeiro: Bertrand Brasil, 2000.
- [18] MORIN, Edgar. Complexidade e transdisciplinaridade: a reforma da universidade e do ensino fundamental. Tradução de Edgard de Assis Carvalho. Natal: Ed. Da UFRN, 1999.
- [19] MORIN, Edgar. Os sete Saberes Necessários à Educação do Futuro. 3. ed. - São Paulo: Cortez; Brasília, DF: UNESCO, 2001.
- [20] NICOLESCU, Basarab. O manifesto da transdisciplinaridade. Trad. Lúcia Pereira de Souza. São Paulo: Trion, 1999.
- [21] NICOLESCU, Basarab. Um novo tipo de conhecimento – transdisciplinaridade. In: 1º ENCONTRO CATALISADOR DO CETRANS. Escola do Futuro – USP. Itatiba, São Paulo – Brasil: abr. 1999(A).

- [22] PLONSKI, G. A. Bases para um Movimento pela Inovação Tecnológica no Brasil. São Paulo: PERSPEC. v.19 n.1, 2005.
- [23] ROCHA FILHO, J. B. Transdisciplinaridade: a natureza íntima da educação científica. Porto Alegre: EDIPUCRS, 2007.
- [24] SANTOS, Marcelo; FUJIKI, Natália Navarro, COSTA Tainá. Comunicação & interdisciplinaridade: algumas notas exploratórias sobre as bases epistemológicas da área REVISTA ELETRÔNICA DO PROGRAMA DE PÓS-GRADUAÇÃO DA FACULDADE CÁSPER LÍBERO. v.8, n. 2, 2016.
- [25] SILVA Jr, J.D.de S. Projeto: O aporte de equipamentos para Instituições de Ensino Superior e de Pesquisa através da ação de fomento de agências federais, estaduais e outros órgãos relevantes. O apoio do PADCT III na aquisição de equipamentos para a pesquisa. Nota Técnica: 07/02. CGEE – Centro de Gestão e Estudos Estratégicos. Ciência, Tecnologia e Inovação. ago. 2002.
- [26] SOUSA, G.M.C. Reflexões do aprender a ser pesquisador na sua dimensão afetiva. Universidade de Brasília-UnB. v. 10, n. 19, jul./dez. 2004. p. 267-280.
- [27] VEIGA, B. V. Modelagem computacional do processo de eutrofização de aplicação de um modelo de balanço de nutrientes a reservatórios da região metropolitana de Curitiba. Dissertação (Mestrado) – Universidade Federal do Paraná, Curitiba. 2001. 140 p.
- [28] VIEIRA, A. M. Admirável Mundo Novo. DIVERSA, REVISTA DA UNIVERSIDADE FEDERAL DE MINAS GERAIS, UFMG. Ano 7, n. 13, fev. 2008.