Towards a transdisciplinary approach in the training of teachers: Creating procedures in learning and teaching in higher education

Sandra Saura-Mas[1,2], Asunción Blanco-Romero[3] , Jaume Barrera[4]

[1]CREAF, Spain, [2]Department of Animal, Plant Biology and Ecology, Autonomous University of Barcelona, Spain, [3]Department of Geography. Autonomous University of Barcelona, Spain, [4]Department of Music and Visual Arts, Autonomous University of Barcelona, Spain.

Abstract

For decades we have been immersed in a constant change in our society, registered together with an increase in its degree of complexity. This greatly affects the currently prevailing educational axioms, making them obsolete, which implies, according to our hypothesis, the need for a process of revision and innovation of existing models. Our proposal starts from a bibliographic review of some existing proposals in innovation, to create a new pedagogical model based on polyhedral and transdisciplinary methodologies. At the same time, we offer a case study in a core subject of the first teacher training course at the Autonomous University of Barcelona. After the practical application of our transdisciplinary methodological theories, it has been possible to successfully collect evidence of a balanced interaction between disciplinary areas by students. The application of the innovations can become a frame of reference for higher education institutions interested in following this very important process of adaptation to social reality.

Keywords: Transdisciplinary methodologies; teaching; strategies; knowledge; complexity; innovation.

1. Introduction

The increasing social complexity, the environmental conflicts and the uncertainties generated by the global economic crisis are bringing new demands and so, new answers to multiple variables. Consequently, a need for the repositioning of academic learning and teaching has appeared: our world requires new ways of understanding while ensuring an integrated perspective on reality. Future teachers should be aware of their role as educators of future citizens of a complex world and so, their training should be orientated to manage a diverse and often conflictive real and virtual public space. The universities are faced to generate and transmit knowledge that promotes innovation, quality and equity while ensuring congruence in the means and methods used. The European regulations promoted in 2001 have been the turning point towards a new curriculum able to re-design the traditional paradigms from a model in which the transmission of knowledge had predominantly been in teacher's hands, towards a new one based on the graduate's competences profile. It was assumed that the training of teachers should be re-oriented towards innovative solutions to prepare them with new methodologies and pedagogical applications able to make them work in an interrelated instead of juxtaposed way. To this objective, the Faculty of Education at the Autonomous University of Barcelona (UAB), Spain, introduced in 2009 a new subject addressed to the first-year students, regardless of their speciality (childhood, primary, social education, pedagogical studies) aiming to reflect about the main ideas and findings that have been shaping the contemporary world. Natural sciences, humanities and social sciences were committed to overlap in an integrated view of reality to promote interest for the natural, social and cultural spheres through critical thinking and to help students to face real problems through a complex approach. The planning of this new subject though, aimed to be a teaching experience where different professional profiles should find a way to orientate the first-year students into a guided reflection about the contemporary world: social and natural sciences as well as other cultural aspects (anthropology, philology, philosophy, biology, sociology, economy, art, and literature) were organised in three multidisciplinary clusters: Society, Science and Culture (SSC). There was a general assumption that traditional disciplinary boundaries were fast eroding and that the kind of disciplinary knowledge that the students needed to develop were changing as well.

Western science is explicitly reductionist, we can learn about the whole by studying its parts, we disassemble and fractionate, as assuming a lego-like world. At this point, the main idea was afforded by the transdisciplinary methodology and the theory of complexity. The qualitative results of the experience presented in this paper have to be analysed in the framework of this subject, Society, Science and Culture, that has been offered to 640 students per year, and carried out by a total of 21 teachers along 10 years. Main objective of this paper is to give evidence of multidisciplinary pedagogical experiences with the aim of constructing a transdisciplinary learning. Concretely, the objectives are: a) a bibliographic review of some

existing proposals in innovation; b) to present pedagogical methodologies to achieve transdisciplinary learning; c) the results of a case study in a core subject of the first teacher training course at the UAB.

2. Findings: New tools to achieve transdisciplinarity education

In order to create the new procedures, the research has been divided into different focuses: transdisciplinarity in education, design of classroom activities (into practice), data collection and organizational aspects and self-training of the teaching team.

2.1. Transdisciplinarity in education

Transdisciplinarity, a concept first used by Edgar Morin, Jean Piaget and Erich Jantsh that meant to 'celebrate the transgression of disciplinary boundaries, an act that far surpassed the multidisciplinary and the interdisciplinary approaches' (cited by Nicolescu, 2002, pp 1) appeared to be the most challenging direction. At the same time, Klein (2001, pg. 246), defined transdisciplinarity as a crossed disciplinary methodology that 'organizes mutual learning and joint problem solving between science and society' and so, transdisciplinary research becomes not antagonistic but complementary to multidisciplinarity and interdisciplinarity research.

Transdisciplinarity connotes a strategy that crosses disciplinary boundaries to create a holistic approach and it is also used to signify a unity beyond disciplines, struggling for a different way of thinking and a different way of organizing knowledge (Max-Neef, 2005; McGregor, 2014). Transdisciplinarity is the result of a coordination between hierarchical levels settled in a pyramid graph. As Max-Neef (2005) suggests, the disciplines at the base of the pyramid describe the world as it is, and it relates the question: what exists? from the natural sciences which explain the basic of the nature to sociology and economics which attempt to explain human behavior. The next level is about what we have learned from the empirical level and what are we able to do and answers the question of what we want to do? The third level is questioning: what should we do? and goes beyond the present and the immediate. It aims at generations yet to come, at the planet.

Placing the debate within the educational context, the teacher is the person who emits and develops a transdisciplinary methodology and the student is expected to achieve a transdisciplinary learning. Transdisciplinary learning should be the exploration of a relevant issue or problem that integrates the perspectives of multiple disciplines in order to connect new knowledge and deeper understanding to real life experiences. Integration is the keyword to increase understanding and constitutes the theoretical background of a 'transdisciplinary dimension', the intellectual space where the links among isolated issues can be explored, the space where alternatives are reconsidered and interrelations revealed (UNESCO, 1998). The

student must be the protagonist of an effective transdisciplinary learning being able to combine and articulate the knowledge provided by the teaching activity. Transdisciplinary methodology concerns which is at once, between the disciplines, across the different disciplines, and beyond all disciplines. The advent and development of transdisciplinarity demonstrate emerging ways not only of organizing but thinking about knowledge and inquiry in a world that has become 'too big to know' (Weinberger, 2011).

In our experience we tried to clearly differentiate between transdisciplinarity, interdisciplinarity and multidisciplinarity while redefining these concepts from the specialized literature and from our experience in their application in education (Klein, 2008). These redefinitions have been done from the point of view of the involved disciplines and from the point of view of the problem to be analyzed and discussed. In order to define our epistemological approach, we have established a clear distinction between the subject/s with a unique point of view towards the problem –disciplinarity-, subjects of different disciplines come together to treat the same problem -multidisciplinarity-, the subject/s with a disciplinary point of view that enriches knowledge resulting from looking at other disciplines – interdisciplinarity-, the subject/s have a global look that goes beyond the boundaries between disciplines, including all the knowledge involved and their relationships–transdisciplinarity- (Saura-Mas et al., 2021).

Working and using transdisciplinary methodology does not mean rejecting a disciplinary perspective, but rather enhancing the understanding of reality by means of a new conceptual framework. For this reason, the transdisciplinary methodology can also include multidisciplinary and interdisciplinary perspectives.

2.2. Into practice: the macro-concept and the polyhedral systems

To achieve this transdisciplinary teaching-learning process, the first step was to agree a consensus within the teacher's team, concerning the setting of the macro-concept (Morin, 2000), which had to be the main learning objective, as well as the polyhedral systems (also called constellations).

The macro-concept: In our experience, the term macro-concept has been used as an integration of order, disorder, interaction and organization, according to Morin's (2000) description and the idea of 'non-belonging' to any discipline was assumed. As a result, the macro-concept allowed all the possible scenarios instead of being kidnapped by a concrete discipline. All the teachers participated in a brainstorming session suggesting, at least, three potential macro-concepts each one, and after debate, the group chooses one by consensus. The agreed macro-concept was 'change', that belongs to a transdisciplinary space of non belonging to any unique field of knowledge. Concerning the learning process, when there is a holistic comprehension of a phenomenon (Kerne, 2005; Choi and Pak, 2006), that it is only prioritized by the macro-concept, the agent of change, then, there is the demonstration of the

understanding of a complexity and a net of knowledge and problems. The setting of a macro-concept since the beginning of the course was a meeting point for the different disciplines involved in the transdisciplinary methodology and learning, to occur more naturally (Figure 1).
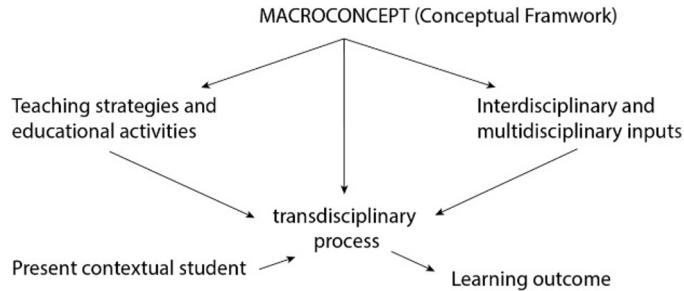
Figure 1. Pedagogical strategy from the macro- concept to learning outcomes. Source: own elaboration

The polyhedral system or 'constellation': This is an activity that consists in the dissemination of 'anchor words/concepts' derived from the macro-concept settled as a central point and from there, particular paths can be defined according to the constellation of concepts/words. Thus, the student constructs the constellation from the main macro-concept and the universe of concepts from the disciplinary cluster sessions (Figure 2). The basic contents and materials afforded by the teaching team from different areas of expertise have determined the elaboration of the constellation by the students.

Figure 2. Picture of the result of the polyhedral system activity. Source: own elaboration

2.3. Data collection and analyses of classroom activity: the macro-concept and the polyhedral system

This educational experience has been analyzed in a mixed system of qualitative and quantitative data collection, with the main goal of verifying the efficacy of the transdisciplinary methodology on the student's learning processes. The last class of the course, data from a whole group of 77 students, at the end of the four year of studies, was collected and analyzed. Concretely, we analyzed the sentences written for each student during

the activity of construction ofa polyhedral system around the macro-concept of 'change'. For each sentence, we calculated the number of mentioned disciplines' clusters (DCn) (Figure 3) as a quantitative value to measure the transdisciplinarity learning achieved by the students. The Academic Coding System (JACS) version 3.0 defined by HESA (Higher education statistics agency) was used to classify disciplines. Each cluster consists of three blocks of knowledge: society, science and culture, and each one of these blocks contain many different disciplines, organized in three clusters.
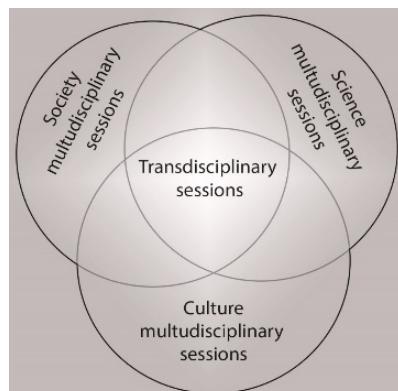
Figure 3. Clusters of disciplines in transdisciplinary SCC course experience. Source: own elaboration

Statistical results indicate a DCn mean of 2.4 +/- 0.11 s.e.. The 36.36 % of students mentioned three clusters of disciplines, and 33.77 % mentioned two (Figure 4). Only 19.48% of them stayed in a single disciplinary point of view. The most mentioned clusters of disciplines were history and philosophy (27.3%), in the second position there was social studies (26.2 %) and in the third site (24.6%) biological sciences.
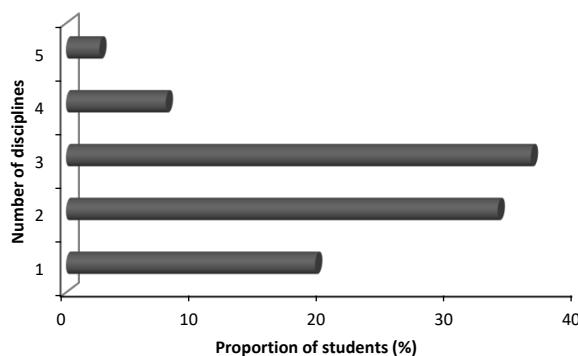
Figure 4. Number of disciplines mentioned by the students in the polyhedral system. Source: own elaboration

2.4. Organization and training of the teaching team

An integrative strategy has been established (Klein, 1996; Lenoir, 2016), for all the 21 university teachers, from 10 different disciplines (ecology, anthropology, geology, plant physiology, human geography, philology, literature, didactic of arts, ethics, and history). They were involved in this subject, based on systematic meetings to define common objectives centered on the macro-concept and the transdisciplinary learning-teaching process.

To set the working planning of the teacher's team, to organize their training and to define the contents for a one-year course has been as important as to set the transdisciplinary theoretical framework and the activities. The traditional lectures had to be substituted by a more flexible organization of learning activities focusing more on the students' improvement rather than on the teachers' timetables.

Then, we organized the course through the year so that there were three blocks, society, science and culture multidisciplinary sessions (10.5h of practical seminars and 15h of theoretical contents, for each block). Moreover, some of the sessions were transdisciplinary (13.5h), with the macro-concept of 'Change' as the main topic, and obtaining as a result, a cluster of disciplines in the subject SSC (Saura-Mas et al., 2021). There was a teacher with a professional area of expertise belonging to each one of the three blocks. In the transdisciplinary sessions, the three teachers worked together before, during and after the sessions.

Constant self-analyses and restructuration have been promoted among the teaching team, so that it has been very important that teachers adapted to conditions that required specific knowledge as well as a holistic comprehension of the world.

3. Conclusions

Concretely, we have established a new theoretical framework of transdisciplinarity in an educational context, and an adaptation of methodologies creating what we call the polyhedral systems methodology. Nowadays, many educational institutions are interested in transdisciplinary education, but often, educators and education managers are confused in the terms, and methodologies. The literature review and proposals of this research can be very useful for future application of transdisciplinarity in educational contexts.

In our experience, it is possible to validate the starting hypothesis in which we propose the need for a process of revision and innovation of the existing models. This objective has been specified in the practical application in the classroom of activities designed in an appropriate way, through tools such as the macro-concept and polyhedral systems.

At the same time, adaptation has been possible thanks to the collection of data and organizational aspects, as well as the coordination and training of the teaching team.

Here we propose theoretical and practical evidence of the effectiveness of this transdisciplinary system success during our learning-teaching processes so that we must reach to apply it in the future as a part of the pedagogical system. There are results of one of our transdisciplinary methodologies, so that we have evidence of the success of it. Most of the students of the case study, 66%, mixed clusters of disciplines on their learning results. One of the main problems of these results is that we already cannot evidence that the student gets from the interdisciplinary to the global view or transdisciplinary thinking. Nowadays, our research group is working in developing some indexes to evaluate transdisciplinary thinking reached by the student after a transdisciplinary learning-teaching process.

Acknowledgements

References

Choi, B. C., & Pak, A. W. (2006). Multidisciplinarity, interdisciplinarity and transdisciplinarity in health research, services, education and policy: 1. Definitions, objectives, and evidence of effectiveness. *Clinical and investigative medicine. Medecine clinique et experimentale*, *29*(6), 351–364. https://pubmed.ncbi.nlm.nih.gov/17330451/

Kerne, A. (2005). Doing Interface Ecology: The Practice of Metadisciplinary. *Proceedings of the ACM SIGGRAPH 05 Electronic Art and Animation Catalog* (Los Angeles, California) August 2005 Pages 181–185. doi: 10.1145/1086057.1086144

Klein J.Th. (1996). *Crossing Boundaries: Knowledge, Disciplinarities, and Interdisciplinarities.* Charlottesville: University of Virginia Press, 1996.

Klein, J.Th., Grossenbacher-Mansuy, W., Häberli, R., Bill, A., Scholz, R.W., Welti, M. (Eds.) (2001). *Transdisciplinarity: Joint Problem solving among science society, technology and society. An effective way for managing complexity*. Springer. doi: 10.1007/978-3-0348-8419-8

Klein J. Th. (2008). Evaluation of interdisciplinary and transdisciplinary research: a literature review. *American journal of preventive medicine*, *35*(2 Suppl), S116–S123. doi: 10.1016/j.amepre.2008.05.010

Lenoir, Y. & Hasni, A. (2016). Interdisciplinarity in Primary and Secondary School: Issues and Perspectives. *Creative Education*, 7, 2433-2458. doi: 10.4236/ce.2016.716233

Max-Neef, M.A. (2005). Foundations of transdisciplinarity. *Ecological Economics*, 53, (1),

5-16. doi: 10.1016/j.ecolecon.2005.01.014 McGregor, S.L.T. (2014). Introduction to Special Issue on Transdisciplinarity, *World Futures*, 70:3-4, 161-163, doi: 10.1080/02604027.2014.934622

Morin, E. (2000). *Introducción al pensamiento complejo*. Barcelona: Gedisa.

Nicolescu, B. (2002). *Manifesto of Transdisciplinarity*. State University of New York Press, Albany, NY.

Saura-Mas, S., Barrera, J., Álvarez, I., Blanco-Romero, A. & Ritondale, E. (2021). *Co teaching transdiciplinario: experiencias docentes*. Servei de Publicacions Universitat Autònoma de Barcelona. ISBN: 978-84-490-9345-6. Bellaterra.

UNESCO (1998). *Transdisciplinarity. Stimulating synergies, integrating knowledge.* Division of Philosophy and Ethics (80 p.).

Weinberger, D. (2011). *Too Big to Know. Rethinking Knowledge Now That the Facts Arent the Facts, Experts Are Everywhere, and the Smartest Person in the Room Is the Room*. Basic Books. ISBN: 0465021425, 9780465021420. 231 pg.