Transdisciplinary approach to sustainable innovation and entrepreneurship education

K. Kövesi
Senior Lecturer
ENSTA Bretagne
Brest, France
E-mail: klara.kovesi@ensta-bretagne.fr

S. Flament
Professor
ENSICAEN
Caen, France
E-mail: stephane.flament@ensicaen.fr

G. Majou de la Debutrie
Head of Sustainability WG
Conférence des Grandes Ecoles
Paris, France
E-mail: gerald.majou@cge.asso.fr

C. Sonntag
Senior Lecturer
ICN Business School
Nancy, France
E-mail: carine.sonntag@icn-groupe.fr

H. Bluteau
Senior Lecturer
AgroParisTech, Université Paris-Saclay
75005, Paris, France
E-mail: helene.bluteau@agroparistech.fr

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INTRODUCTION

In France, there is a noticeable and contunually growing interest in sustainable development education strongly supported by the legislation (from the “Loi Barnier” introduced in 1995 and later the “Lois Grenelle” in 2009 and 2010) and by civil organisations (CPU, CIRSES, etc.). As it was outlined in the latest annual report of CGE [1] (Conférence des Grandes Ecoles – a French national organisation gathering together directors and leaders of engineering, management and business schools), sustainable innovation and entrepreneurship education became a central question for higher educational institutions (HEIs) despite the existing discrepancies on regional level. According to Prevost and Jouffray [2] this interest to integrate sustainable development in their educational activities is particularly strong in engineering schools. The introduction of sustainable development education in the accreditation criteria’s in 2014 by the French commission of accreditation (CTI - Commission de Titre des Ingénieurs) generated a real change not only in the way of thinking about the importance and place of sustainable development education in engineering education but also in the practice of French engineering schools [3].

Despite this keen interest, there are few available open-access teaching materials for sustainable development education focusing on entrepreneurship and innovation subjects. For this reason, the main purpose of our work was to create a highly adaptable new teaching material to raise students’ awareness about sustainable entrepreneurship and innovation issues. This objective is in line with the CGE’s Sustainable Development Chart [4] encouraging their members to integrate the challenges of sustainable development in the educational program progressively. Moreover, this is among the main priorities of HEIs in France [5] in coherence with the European Commission entrepreneurship 2020 action plan [6]. This new and innovative teaching material will be open-access and widely spread in France between all HEIs members of the CGE (not only for engineering students but for other students feeling interest in this subject).

In this paper, we aim to provide guidelines for the design of teaching materials for sustainable development education based on the Transdisciplinary Case Study (TCS) approach. This work is based on our experience in the CGE’s Sustainable Entrepreneurship and Innovation Working Group in France. The members of our multidisciplinary working group are teachers and researchers in divers HEI’s (engineering, agriculture, management, etc.) who have a specific interest to make a contribution to sustainable development education. We consider sustainable development as one of the major issues of our modern society, and our work is motivated and founded on this common interest.

TRANSDISCIPLINARY FRAMEWORK

Transdisciplinary is a relatively recent construct developed by Piaget in 1970 with the evolution of disciplinarity in order to help a better understanding of the modern world with growing complexity. He defined transdisciplinary as a 'superior stage' of interdisciplinarity 'which will not be limited to recognise the interactions and/or reciprocities between the specialised researches, but which will locate these links inside a total system without stable boundaries between the disciplines' [7:144]. For Edgar Morin, transdisciplinary represented the liberty of thinking 'between disciplines' (or go-between disciplines) that allows an exchange by creating a link between them. According to his definition, all 'knowledge is relevant only if it can fit into a context and the most sophisticated knowledge, if it is completely isolated ceases to be relevant' [8:3]. In 1985, Nicolescu involved the meaning of 'beyond disciplines' in the definition, for the reason that in our modern world 'disciplinary knowledge has reached its own limitations with far-reaching consequences not only for science but also for culture and social life' [9:21]. From this perspective, disciplines are considered in their social context in a holistic way, not separately from the real world and taking into consideration their interdependence [10].

The relevance of the transdisciplinary research and sustainability is widely recognised, almost considered as mainstream today. Besides, it is evidence that there is a close link between the transdisciplinary approach and sustainability issues to find a solution to a problem in a complex societal context [11]. In this case, transdisciplinary learning allows us taking sustainability issues from their starting points and exploring them from the angle of various disciplines applying an integrative perspective to find an effective solution [12]. Consequently, transdisciplinary learning is a well-adapted form of learning in sustainability education to tackle with real, complex and socially relevant problems. As it was highlighted by Merck and Beermann [13:24] 'transdisciplinary teaching can have a positive influence on the motivation of graduates, especially in sustainability programs, and allows an active imparting of practice-based knowledge'. Also, the application of transdisciplinary teaching is particularly relevant in the situations when there is a high level of discrepancy between the logic of sciences as it is the case between engineering and social sciences.

In engineering education, transdisciplinary teaching and learning is broadly recognised and viewed as an excellent way to develop engineering students' capacity to apply a holistic view and not to be limited only to their technical disciplines. As it was pointed out by Jeder [14:130] transdisciplinary teaching has numerous advantages for students' sustainability skills and competencies development as 'opportunity for motivation, inspiration and stimulation of the interest in knowledge and exercise of critical thinking and creativity…diversity in the way of thinking, feeling and living and opens decks to a modern understanding of the world and life which school should prepare'. For Nicolescu [15] each discipline should devote approximately 10% of teaching time for transdisciplinary so as to develop a larger perspective. According to Tejedor and Segalàs [16:7088], the integration of transdisciplinary teaching and learning in engineering curriculum allows for training a 'new brand of an engineer' who 'thinks critically about the co-construction of public welfare and the technological systems'.

From the beginning of the '90s, the 'Transdisciplinary Case Study - TCS' is viewed as a powerful and particularly well-suited method to conduct sustainability learning

using unstructured cases with qualitative data in a real-world context for complex and socially relevant sustainability issues [17]. For Steiner and Posch [18] this appropriate method for sustainable development involves learning not only for the students but also for the teachers and participating practitioners as it is based on a mutual learning process between them.

TEACHING MATERIAL DESIGN

For the teaching material design, we developed a five step iterative process based on the process for TSC defined by Scholz and Tietje [19] from the goal definition until the final validation.

1.1 Goal definition

This first step of our teaching material design aimed to develop the mutual understanding of the issue, including the formation of guiding question, in order to define our objective. Despite our common interest in sustainable entrepreneurship and innovation education, our multidisciplinary working group had a very different vision about the possible objectives depending on our disciplines and professional culture. After several sessions of discussion, we were able to create a collective perspective and a new meaning for all of us with the application of a transdisciplinary approach. Consequently, the goal definition was based on valuable mutual learning process between us, as it was indicated by Steiner and Posch [18]. We decided not to focus on a specific question of sustainable entrepreneurship and innovation but rather to offer a broad vision to the students. We thus defined a future-oriented objective: stimulating and inspiring students' motivation and raising their awareness for future investigations and actions.

1.2 System building

Based on the recommendations of Scholz et al. [17], we opted to the application of multiple case studies with unstructured cases that is better adapted to the transdisciplinarity approach than the application of single case study. From an epistemological point of view, our new teaching material has an exploratory nature that is compatible with this choice. For the problems' structuration, we were based on the widespread Sustainable Development Goals (SDGs) defined by the United Nations. As our main objective is to offer a broad vision for students, we defined as our imperative to address the maximum possible of these goals but at least one of them for each case study. For the system building, as an innovative solution, we defined a structural matrix with treated goals, in the face of various contextual situations and disciplinary perspectives as the third dimension.

1.3 Scenario construction

For the scenario creation, we selected complex and multi-faceted real-world problems occurring in our modern society generating a significant social or societal impact. In order to provide a broad transdisciplinary vision, each member of our multidisciplinary project team participated in the scenario construction allowing us to integrate into the scenarios the vision of various disciplines (e.g., engineering, management, agriculture, marketing, social sciences, etc.). For the scenario description, we followed the guidelines defined by do Prado Leite [20:49] and tried to avoid the main weakness as the minor semantic problems or the lack of homogeneity or perspectives. Also, we aimed to follow the structure of our matrix system and develop scenarios in order to fill it in a most optimised and relevant way.

1.4 Assessment questions

In the framework of the assessment process, we defined multi-criteria assessment questions based on the four following issues: general definition, perceived values, stakeholders' role and applied strategy. For the development of assessment questions, we implemented a multi-logic thinking approach requiring students to combine the knowledge of different disciplines and using multifaceted reasoning inciting them not to give the immediately obvious answer to the questions. The application of multi-logic thinking approach was guided by our intention to avoid a simplified assessment including traditional step-by-step logic considered as less adapted in the case of transdisciplinary approach toward sustainability learning.

1.5 Validation process

For the validation of our new teaching material, we applied a two-step, intern and extern validation process. At first, we carried out an internal validation with the participation of our working group members to discuss the areas of consensus or divergences in each case study and provide a first impact description with future orientations. Secondly, the external validation by academic teachers, researchers and practitioners in the framework of a workshop dedicated to investigating their opinion as independent experts [21]. This external validation step is particularly challenging as it gives a first external vision of our work judging his diver's facets.

RECOMMENDATIONS

Despite their high interest and willingness, engineering HEIs have several difficulties to introduce sustainable development education effectively. As the experimental study of Prevost and Jouffray [2] questioning institutions, teachers and students revealed one of these major difficulties is linked to the definition of the sustainable development education. Teachers in diverse technical disciplines feel not really legitimate and competent to teach sustainable development issues which they do not manage the whole understanding. For this reason, applying transdisciplinary approach in the design of pedagogical dispositive is essential in order to allow a holistic understanding of sustainable development issues. However, our experience pointed out the difficulties of the application of transdisciplinary approach in the development of teaching materials.

The first obstacle could be for engineering schools to work out new transdisciplinary teaching materials is to get together a multidisciplinary team. In our case, the initiative and support of CGE was a critical condition of our work as we had the opportunity completing it in the framework of a well-organised working group with membership from very different HEIs from various French regions and all of us specialised in diverse disciplines. As our case shows, an existing and well-established multidisciplinary professional network could greatly facilitate the application of the transdisciplinary approach.

Secondly, at the beginning of the work process, our working group had very divergent ideas and perspectives about the meaning of education for sustainable entrepreneurship and innovation. For creating a mutual understanding and finding the way how to work together, we needed to take our time to discuss and understand each other views. We wanted to achieve not only a 'cross-disciplinary borrowing' [16:7086] but removing the limitation between our fields to thinking 'beyond disciplines' [9]. It was evident that the application of transdisciplinary approach requires close collaboration between our working group members, but we widely

underestimated the difficulty and time needed for this first step of conceptual definition. However, this major difficulty at the beginning of the work could decline the group dynamic or in certain cases causes the dissolution of the working group. To avoid this situation it could be useful to consider this difficulty of multidisciplinary collaboration in advance to be able to provide communication and coordination support [22].

We have to highlight that the interface has a significant role in the whole system design process. We used the platform SULITEST having a special mission to support sustainable development education and in particularly sustainability literacy. The vision and assignment of this platform are perfectly in line with our mission and could allow us to widespread our work not only on the national but also on the international level. The features and constraints of this platform were taken into consideration from the beginning of our work for achieving good system adaptability.

In the scenario construction, the selection of real-world cases was a real dilemma of our design process. We raised the question about the adequate complexity level and broached SDGs goals of our selected cases. As noted by Steiner and Posch [18], too high complexity level could cause the frustration and demotivation of students while too low complexity level could be perceived as unrealistic and demotivating for acquiring additional knowledge. Accordingly, the most adequate solution seems to be selecting real-world cases in line with our objectives. For example, our main objective was to give a broad multidisciplinary perspective for our students, so we tried to select heterogeneous cases with limited complexity but giving sources of complementary information. In this case, they have the possibility to enhance the complexity level of their case studies if they want to gain added knowledge.

CONCLUSION

Sustainable entrepreneurship and innovation education for engineering students is a very complex subject that includes not only technical but environmental, ecologic, economic, social or societal dimensions. Consequently, the application of transdisciplinary approach for the development of innovative teaching materials is highly relevant to train modern holistic engineers. However, to put into practice a transdisciplinary teaching materials design process for a multidisciplinary team involves several difficulties. Our experience shows that close collaboration between our working group members and high level of commitment in the same way at the personal and institutional level were essential for this work.

At this time, we are at the end of the internal validation process and preparing our national workshop for the external validation. Following the validation, we intend to implement our new teaching materials on the French national level with the help of the CGE’s network. As a future perspective, we would like to explore the perception of engineering students and their teachers about the efficiency of these new teaching materials. More specifically, to investigate engineering students about their perception: What kind of sustainability skills and competencies could they develop with it? What are their motivations? What is the real effect of this transdisciplinary pedagogical approach?

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