

Biomimicry: transformative learning for sustainable solutions

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Abstract

Biomimicry is an emerging discipline that aims at finding more sustainable solutions to human challenges through nature's emulation. Biomimicry is multi/interdisciplinary as it calls for the collaboration among diverse disciplines. Jargons, different perspectives and mindsets characterizing the various disciplines obstruct the knowledge sharing and the creation of new cultural forms during the bio-inspired design process. A methodology for the bio-inspired design, grounded on the theory underlying the boundary-crossing processes is proposed. The methodology will be tested in multidisciplinary class formed by universities of applied sciences students. The preliminary results will be discussed and eventual refinements to the proposed methodology will be illustrated.

Theoretical framework

Ongoing trends and patterns of natural-resources use, the inability to cope with the complexity and interconnectedness of our society and the rapid technological change are impacting the human-environment interactions in an unsustainable manner. So far, these human challenges have been mainly addressed with a mono-disciplinary approach which resulted to be very ineffective. The solutions obtained with this approach do not consider interactions and the effects on the society, economy and environment. As a consequence, the proposed solutions likely will shift the problem to a different context. Therefore a more holistic and multi/interdisciplinary approach is necessary to find authentic sustainable solutions to human challenges. Universities of applied sciences, as they are devoted to the formation of future professionals, have to devise new ways to stimulate the multi/interdisciplinary approach and crossing-boundaries skills for students with different backgrounds. A new emerging discipline that can play a prominent role in this endeavor is biomimicry. It can be considered as an approach to innovation that seeks sustainable solutions to human challenges through nature emulation and banks on the idea that nature, i.e. animals, plants, microbes, etc, has already solved many problems we are still struggling with. Biomimicry is multidisciplinary as it calls for collaboration between very different disciplines (engineering, economy, chemistry, material sciences, biology, etc.). These different disciplines have evolved with a reductionist approach and developed different jargons, perspectives and mindsets which obstruct knowledge sharing. In order to express itself, biomimicry needs to be approached with an interdisciplinary process, which can only develop by crossing the boundaries of various disciplines. Akkerman and Bakker (2011) defined a boundary as a socio-cultural difference causing discontinuity in action and interaction, and therefore boundary crossing is related to a person's transition and interactions across different domains (Akkerman & Bakker, 2011). So, teaching biomimicry cannot disregard the answer to the question: what dialogical learning mechanism takes

place at the boundaries? In their review article, Akkerman and Bakker (2011) have identified four learning mechanisms that take place at the boundaries: **identification, coordination, reflection and transformation**. In this context learning, in the broad sense, encompasses new understandings, identity development and change of practices. The learning mechanism that fits with biomimicry is transformation. Even though identification and reflection, both involving the explication and visibility of perspectives, seem conditional for transformation because in the latter boundaries need to be encountered and contested before using them for co-developing practices. Biomimicry requires profound changes in practices leading to the creation of new, in-between practices usually defined as boundary practices. Thus, in this framework biomimicry can also be defined as transformative learning. Transformation always starts with a **confrontation** process in which a lack or problem forces the intersections of different domains to change their current practices and interrelations. A second process that takes place is the **recognition** of a shared problem space which is bounded by the confrontation. For biomimicry the shared problem space is the environment (biome, ecosystems) which is affected by several interconnected problems rather than a single biological system with a specific problem. A third process in the transformation is **hybridization**. Given a certain problem space, ingredients from different contexts and crossing-boundaries practices are combined to form something new and unfamiliar. A fourth process is the **crystallization**: what has been created needs to be embedded in the practice so that it has real consequences. The research activities hereby proposed intend to answer the question: how can the biomimicry practice guide students in transformative learning?

Methods

Biomimicry is a practice-oriented discipline thus the main learning goal of teaching biomimicry is to provide the students with skills and expertise enabling them to go through the Bio-Inspired Design (BID). Fig. 1 provides a graphical representation of steps composing the bio-inspired design (Helms et al., 2009).

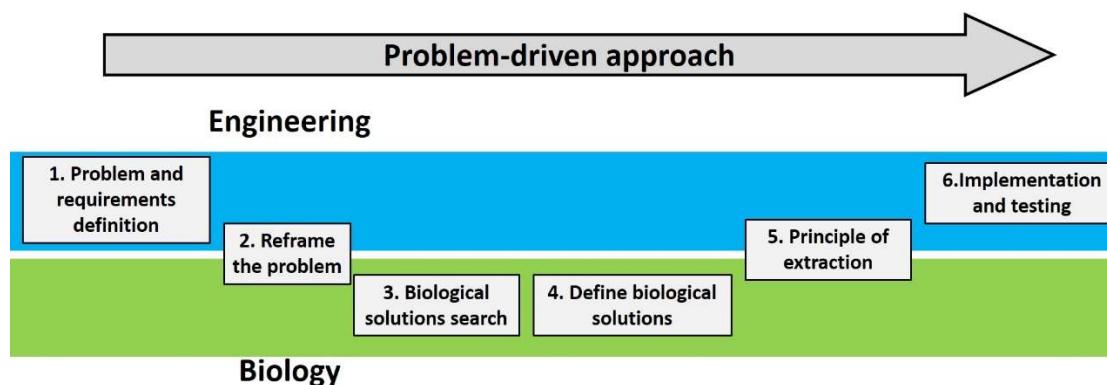


Fig. 1 - Steps of the problem-driven design approach

The BID needs to be preceded by activities in which the processes of confrontation and recognition are addressed. These activities, encompassing both formal/in-class (lectures, examples, etc) and informal/out-of-class (excursions in nature, company visits, etc) teaching activities, aim at

- making the students aware that more sustainable solutions can be found with a multi/interdisciplinary approach and by crossing boundaries of different disciplines;
- making the students aware that they will contribute to the creation of a more sustainable future;
- motivating the students in looking for solutions by emulating nature;
- defining the shared problem space.

These preliminary activities will facilitate the bio-inspired design because the students, aware of the necessity of changing their practices, will be more resilient while coping with the struggles (working out of your comfort zone, different perspectives, language/communication problems, etc) associated to multi/interdisciplinary process.

The BID starts with the problem and requirements definition. The problem needs to be reframed (see step 2, Fig. 1) in order to make it understandable for students involved in the design. The challenge needs to be expressed in terms of functions by using words/verbs not belonging to any specific “jargon”. In the problem reframing the process of the hybridization takes place. We aim at stimulating this process through the implementation of knowledge building dialogues (Bereiter & Scardamalia, 2016) and the use of boundary objects such as software for monitoring the reasoning and thesaurus (biology to engineering, engineering to biology). Once the problem has been clarified, the search for biological systems which can inspire possible solutions can start and the biological system which exhibits qualities and properties that best fit with the requirements defined in the step 1 will be selected. In step 5 (Fig. 1) a further hybridization process is necessary to extract biological system functioning through the removal of specific structural and environmental constraints. The last step includes the operations of implementation and testing of the bio-inspired solution and it can be considered as a crystallization process because the knowledge generated by crossing the boundaries will lead to a product/service that can be used.

Preliminary findings and conclusions

The first biomimicry teaching experience started in a mono-disciplinary context, formed by industrial design students, in which the biology students acted as “external consultants”. The interaction between the students of two different disciplines resulted to be ineffective. Industrial design students tended to focus on designing something beautiful and elegant without being engaged in the BID and the underlying sustainable goals. The biology students had a weak motivation in interacting with the industrial design students as they experienced that the value of their knowledge was underestimated. The findings of these preliminary biomimicry teaching experience have stimulated the elaboration of the teaching methodology described in the previous section. In the coming months we aim at testing the

proposed methodology in an authentic multidisciplinary class and the preliminary results will be discussed and eventual refinements to the proposed methodology will be illustrated.

References

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