Innovation is a complex construct, a rather ambiguous term that nonetheless has recently gained broad interest from academic, industry and mass-media circles. The idea of change has arguably gained popularity in a world with ubiquitous crises in the economy, the environment and the social spheres. In this context, some design schools are evolving their approach to design from the creative process of imagining and developing original manufacturable products into a more systemic approach where creativity is applied in ambitious innovation projects that address problems which “wickedness” transcends any artificial disciplinary academic boundary.

At the Design School of Tec de Monterrey Mexico, this is reflected by their recent motto “Design is only possible between disciplines”. This design school has built in its ten year history strong bonds with the Engineering and the Business faculties, as well as with external organisations and companies in the Bajio region of Mexico including SMEs, NGOs and government agencies with whom students and faculty members have collaborated extensively in design studio courses from semesters 3 to 9 of the Industrial Design Bachelors programme.

This article presents twelve insights from the last five years of interdisciplinary collaboration between three academic departments: Industrial Design, Electronic Engineering and Business Entrepreneurship. Its aim is to present concrete experiences to help other design schools and companies implement the type of initiatives that are likely to contribute towards innovative practices. These experiences are derived from personal participation and reflection; they reveal as much about other disciplines as they do about designers, and their idiosyncrasies.

1. Comprehensive innovation
In working across disciplines, we have noticed that the term ‘innovation’ is highly polysemous. While in general it refers to a process of adding value, this means different things in different disciplines. Although every discipline uses a host of implicit and explicit definitions, the following list depicts the more idiosyncratic depiction of the term for each discipline in our experience.

- Innovation is used in Business and Entrepreneurship circles to describe a qualitative increase in profit or market share. Therefore, innovation cases heralded in the Business literature invariably refer to success in sales.
- In many Engineering contexts, innovation directly refers to pushing the existing technological boundaries. Documented cases in the literature often include laboratory inventions that change current assumptions of what is possible.
- In Creative Design, an emphasis is placed on meaning, and innovation is considered a radical change of expectations associated to a new practice, service or product.

These three types of innovation, i.e.: business innovation, technological innovation and semantic innovation (or “design-driven”), are complementary rather than mutually exclusive. In fact, a comprehensive definition of innovation would include market success, technological accomplishment and a radical departure from expectations, among other things. Whilst crafting a definitive definition of innovation may be beyond interest, what is important in an interdisciplinary context is to be explicit and empathic in the clarification of aims and targets. In our experience, this is crucial to enable communication, project alignment and productive collaboration.

2. Never ask “Are you creative?”
There are two natural answers that people give to the question “Are you creative?” and we have seen that both answers (yes or no) are equally counterproductive to innovation. When people believe that they are not creative, they build a ‘suicidal’ attitude towards change. This is a frequent occurrence in Engineering and other circles where creativity is associated to playful, trivial imagery exercises. In contrast, most people in so-called creative industries tend to believe that they are creative and that this attribute is necessary or even sufficient for innovation. When people believe that they are not creative, they build a ‘suicidal’ attitude towards change. This is a frequent occurrence in Engineering and other circles where creativity is associated to playful, trivial imagery exercises. In contrast, most people in so-called creative industries tend to believe that they are creative and that this attribute is necessary or even sufficient for innovation. This is a dangerous assumption and one that often drives forward-thinking people to deep levels of frustration and teams to high indices of polarisation - and ultimate failure.
In our experience, innovative teams need a balance between “creative” and “non-creative” members, or rather, we have learned that labelling people this way is damaging to innovation in both ways. Truly innovative teams are those where people know that they can switch from “more creative” (divergent exploration) to “more productive” (convergent implementation) mode irrespective of their backgrounds. Such teams display flexible leadership, which shifts from members with more divergent thinking in certain stages of a project, to other members with more convergent skills at other times.

Creativity specialists are to be avoided from innovation teams. Instead, it is more productive to assemble a set of humble and respectful specialists that are able to transfer leadership and switch between creative and productive stages, triggering different abilities from every team member throughout the development of a project.

3. Systemic interventions

Innovative teams develop systems thinking skills and build new proposals of systemic interventions knowing that any resolution to a problem is merely a way to further understand problems and “dance with systems”. One way to help teams with this process is to introduce a guiding framework such as Donella Meadows’ “Twelve leverage points” in order to build a common ground. This type of guide helps to frame discussions, share ideas and assess arguments and equally important they help teams avoid labour division by disciplinary turf.

Teams should proceed with caution in regards to systemic thinking, as introducing people to complexity tends to cause undesired responses. Rather than avoid such responses, teams should be prepared to overcome their effects and transcend them. A number of stages can be expected in the process of building systemic teams:

- Doubt and denial is not an uncommon early response when people first approach problems from a systemic perspective. At times, this stage is not entirely superseded and teams may be constantly tempted to replace a systemic viewpoint with a more simplistic way out of it particularly if artificial deadlines are imposed.

- Realisation is observed when teams are able to grasp the complexities of a problem and visualise it from multiple perspectives, scales and dimensions including technology, society, culture, the environment, the economy, politics, etc.

The risk here is that teams iterate infinitely in fascinating analysis of problems and continuously postpone action—see below.

- Paralysis occurs when teams are overwhelmed with the amount and nature of information. Conflicting goals, numerous requirements and unclear limits are likely to trigger a sentiment of helplessness. The risk here is that teams become unable to initiate and implement new actions.

- Motivation takes place when teams see “the light at the end of the tunnel”, usually after a crisis or a turning point in the process. This inspiration may arise from a key insight, an analogy from a distant domain, a new or overlooked piece of data, or a change of focus. This is a positive occurrence but may become counter-productive if a team becomes fixated with these ideas instead of taking them as stepping stones in the learning process.

- Systemic action is the natural target of the entire process. After all the data gathering, analysis and decision making, a concrete and plausible course of action is desired. The risk of this stage is that teams forget to engage in continuous periods of reflection that lead to learning. A further risk is that teams end up with extremely complicated solution proposals where all the system variables are included. Truly systemic interventions are akin “nudges” or small scale actions that trigger self-sustained and large-scale change.

4. “Just tell me what to do”: dealing with premature action

A common trap in which teams tend to fall is to start solving a problem as soon as it is presented to them. This is particularly true in academic circles where students are presented with what is assumed to be a definite construction suitably prepared for them to apply and demonstrate what they have learnt. We have seen that most teachers continue with the practice of framing problems or projects where they know the target response or solution. This is actually the basis of most grading rubrics, to help assess how far is the final outcome to the desired target. In our experience this is a major block to both creativity and innovation.

Innovative teachers, managers and team leaders in general know that their framing of the task or problem at hand is an early approximation that is due to evolve thus they start by proudly acknowledging that they don’t know the final answer. This implies a non-trivial shift of control that requires careful planning and management, but the solution space expands and often leads to new learning opportunities for everyone.

Innovative teams learn how to find a balance between naming and solving a problem. One of the most challenging skills that such a team requires is tolerance for ambiguity. This is even harder for
technical savvy people who are trained to do things right, rather than to question if they are doing the right things.

5. “Complex is complicated”: dealing with excessive thinking
In contrast to the previous point, in our experience teams may conversely fail to innovate due to an excessive pondering of the problems at hand, rather than translating information into actionable insights and finally into concrete action. Such teams insist on developing a comprehensive understanding of the problem before deciding a resolution course. The idea that “problem understanding and problem resolution are concomitant to each other” reinforces the notion that no amount of analysis solves a problem.

6. Novelty bias
The quest for pure originality is flawed. A healthy dose of imitation is good as long as it includes learning. In all disciplines there is an emphasis on “being first”, this is noticeable in concepts like “first-mover advantage”, the logic behind the patenting system and the drive for originality in creative design. However, most cases of comprehensive innovation demonstrate that there is a clear advantage in learning from early ideas and improving them in order to achieve a balance between what has been called “the three lenses of innovation”: feasibility, desirability and viability.

In our experience, every well-known innovation in history is based on very specific instances of preceding failures or instances of prior art in a different context. This is called the n-th mover advantage and can be extremely helpful to align interdisciplinary efforts, as it lifts the burden from any single discipline to “deliver” innovation in a design project. All innovations cite multiple prior art references, and often times it is ignorance mixed with our tendency towards attribution effects rather than pure originality and unprecedented genius what explains seemingly breakthrough innovations: feasibility, desirability and viability.

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It is important for interdisciplinary design teams to realise that innovation thrives in the links rather than the nodes of the knowledge networks.

7. Most innovative ideas are actively rejected
An additional common misconception in innovation projects is that the team’s goal is to find “the next big thing”. Brainstorming sessions (often fun and more productive to build group ties rather than good ideas) are becoming ubiquitous to address all problems from organising the end-of-year party to increasing sales or decreasing costs. In our experience, such sessions are often flawed from the beginning in that their objective is to generate a vast number of ideas, rather than try to assess, learn and understand what both new and old ideas really mean when developed into tangible solutions.

The reason why most breakthrough innovations are perceived as “obvious” once they are implemented is that they are indeed obvious - once we understand them. There are two sides of the coin behind such a truism: firstly, most innovations aren’t “first to the world”, in fact many of us may have had the same or a very similar idea. In this case the difference often is that we didn’t do anything about it, we chose not to invest the resources and efforts to implement our great idea. A second alternative is that the idea seemed chaotic or plainly stupid before it was implemented. Clay Christensen refers to this type of solutions as disruptive innovations: successful ideas that most competitors are unwilling or unable to see, or that they very consciously reject or dismiss as inconsequential.

8. Language and documented cases are important
Many of the biggest challenges for interdisciplinary teams are related to language: team members carry conventions from their disciplinary and experiential backgrounds that are articulated in ad-hoc vocabularies.

Team members from creative backgrounds tend to perceive technical skills and knowledge as hard to approach mainly due to language barriers. In our experience, the main challenge associated to explaining technical concepts to an artist or a creative designer is to overcome the resistance that the word creates when they first encounter it. Often times their reaction once they understand the underlying concept is a perplexed “is that it?” indicating that it sounds more difficult than it actually is. We have found this to be a general case rather than the exception.

A fundamental difference concerning specialised issues is that although domain experts may need to dwell on the specifics and detailed intricacies, for an outsider this is unnecessary. Simpler, more applied and meaningful explanations are required to introduce other disciplines to the fundamental concepts and techniques. We have observed that for technical experts it is equally challenging to apprehend the type of indefinite and ambiguous terms that are commonplace in human sciences. Outsiders often try to find an equivalent structured approach to concepts finding the exchange of such ideas frustrating.

Interdisciplinary teams that aim to innovate may find support in well-documented cases to enable communication. In our
experience, it pays to have a collection of cases at hand where issues from multiple fields help explain success or teach us something valuable from failure. Some of the cases that we regularly employ include:

- **Thomas Edison** vs. **Emile Berliner** competition in establishing the phonograph industry (cylinders vs. discs) to illustrate the process of learning from stakeholders’ feedback
- **Segway** to illustrate the idea that technical accomplishment is an insufficient ingredient for innovation
- **Reusable diapers, menstrual pads** and other disposable products being replaced by washable and reusable alternatives to illustrate the change of everyday expectations and meanings that are seldom questioned
- **Stereobelt** vs. **Sony Walkman** (and a number of Apple products) to illustrate the power of n-th mover advantage
- **European camel milk** from Kamelenmelkerij Smits in Holland to illustrate the importance of imitation with learning in a new context
- **Ebook readers** to illustrate the time it takes for a market to assimilate a new proposal
- **Calculators, telephones, ATMs keyboard layouts** to illustrate the evolutionary process of convergence and the emergence of norms and conventions
- **Bicycles** to illustrate the diverse range of meanings that these human-powered vehicles have around the world
- **Wright brothers airplane** to illustrate that a new idea can take decades before people accept it and recognise it as “obvious”
- **Nintendo Wii** to illustrate that a deep change of meaning and expectation is possible even when the technical components are not new
- **Vibram fivefingers** to illustrate how research can be applied in the design of products that challenge underlying assumptions
- **Flip pocket camcorder** to illustrate the success of a ‘worse’ solution in creating a new product category
- **Buckminster Fuller Dymaxion car** to illustrate the importance of the long-term negative effects (the car) and how they can be anticipated
- **Ford Model T** to illustrate the importance of learning from failures in previous versions (Models A, B, C, etc).
- And many lesser-known and small-scale examples of adaptation, improvisation and innovation from social groups living in poverty and hardship.

This type of examples serve to articulate dialogue, guide discussions and raise the importance of continuous learning across disciplines in order to understand where innovation is appropriate in every case: technology-push, market-pull, change of meanings, or possibly a balanced and comprehensive approach.

9. **Applying research outcomes**

In every discipline, there is a theory-practice gap between the output of research efforts and their application in addressing problematic situations. When working across disciplinary boundaries such distance widens between different knowledge traditions and types of practice. Interdisciplinary teams invest significant resources in building respect and nurturing disciplinary diversity in order to translate and integrate complementary research findings from different fields.

In academic circles, the challenge increases when promotion and tenure evaluation systems reward disciplinary over-specialisation. Innovation requires flexible assessment criteria to promote collaboration initiatives in research as well as teaching and consulting.

10. **The power of mastering soft and hard skills**

A damaging practice when interdisciplinary teams are formed is to assign to each discipline their specialised tool set and roles. Namely, teams often assume that designers should be in charge of drawing, engineers should write computer code, and business experts should evaluate revenue models. Fortunately, the idea that sketching should be taught in all disciplines as a thinking aide has been raised in recent years.

In our experience, all members in innovative teams engage in drawing or in computer programming or in identifying new business opportunities. It is this type of combination of knowledge and skills that shape the type of contradictory profiles that have been associated to creativity and that are necessary to cultivate polymaths.

11. **Diversity in teams**

Creativity techniques are useless if the members of innovative teams engage in routine everyday activities and habits. Imaginative people enjoy exploration, experimentation and the failure associated with trying new things. Successful teams incorporate members who are comfortable talking to different people (age, discipline, ethnic background, religion) and cultivate a wide range of tastes.

We have observed the processes and outcomes of two distinct types of groups: teams composed by strangers and teams...
composed by acquaintances\textsuperscript{12}. The former tend to be less efficient but they surpass others in originality and quality. The latter are highly efficient but their results tend to be below average. Interdisciplinary teams develop the capacity to switch between these two strategies. They are able to switch from early stranger-like dynamics when emphasis on differences is required to enrich divergent processes into later acquaintance-like dynamics when the aim is to enable agile and focused decision-making to act and implement original initiatives efficiently.

12. Unintended and indirect consequences

Lastly, in our experience interdisciplinary teams can be highly innovative due to their potential to anticipate unintended and indirect consequences of a change initiative. Because systemic change cannot be tested without being implemented, innovation requires different ways to assess the potential of a proposal, learn from small-scale trials, and develop an understanding from solutions throughout implementation. Successful teams listen to and learn from feedback, and therefore are able to change course of action based on new evidence. This may lead a team to constant trade-offs and dilemmas, and even to deep means-ends questioning in regards to the direction and scope of change sought. Likewise, innovative teams learn to appreciate change resistance. They receive negative responses as a valuable source of insights and as an opportunity to address challenges and improve previous change initiatives.

By way of main conclusion, this range of experiences has shown us that innovation is necessarily interdisciplinary. This may be one of the most understated and challenging issues behind innovation. In this article we have tried to distill from our experience key factors that are likely to contribute to the creative development of meaningful and profitable technology that promotes sustainable lifestyles into the twenty-first century.

Reference

5. A famous quote by A. Einstein reads: “If I had an hour to solve a problem and my life depended on the solution, I would spend the first 55 minutes determining the proper question to ask, for once I know the proper question, I could solve the problem in less than five minutes”