

Systems thinking, disciplinarity and critical thinking in relation to creativity within contemporary arts and design education

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Abstract

Pink (2005) discusses six critical competencies or senses required for the conceptual age. They are design, story, symphony, empathy, play and meaning. This paper will focus on mainly on design, within arts and design education, exploring relationships between systems thinking, multidisciplinary, critical thinking and creativity from the perspective of Industrial Design (ID).

Initially, the paper presents a brief historical approach to the evolution of 'systems thinking'. Afterwards, multidisciplinary is discussed in relation to design disciplines and examples illustrate the use of systems thinking in multidisciplinary design projects at different scales.

Subsequently, tangible aspects of interdisciplinary collaboration and systems thinking in design education are discussed through a case study of an academic transport design project developed between the 2nd year ID studio of the University of Canberra (UC) and the ACT planning and land authority (ACTpla). The main relevant aspects of this collaborative industrial design studio, such as working with the government and other design disciplines (landscape architecture and architecture), as well as the systems thinking focus is described and analysed.

Main conclusions propose that 'creativity' in contemporary arts and design education can be enhanced through systems thinking and interdisciplinary or multidisciplinary collaborative work. Creativity is also complemented by critical thinking (as an important evaluative and decision-making tool) in today's complex post-industrial, digital and sustainability-focused society. This within the context of the 'contribution of the creative class' (Florida, 2002) and a 'new world in which inventiveness, empathy and meaning predominate' (Pink, 2005)

Key words: creativity; arts and design education; industrial design; transport design; systems thinking; multidisciplinary; interdisciplinarity

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Systems thinking: from natural sciences to design

This brief overview provides mainly a historical background to understand why systems thinking, which originated mainly in the life sciences, is so relevant today to creative disciplines of arts and design.

The idea of a spiritual, organic and living universe based on Christian theology and Aristotelian philosophy was largely accepted until the 16th century, when Rene Descartes first introduced the concept of ‘mechanism’ (Capra, 1996). This concept has assumed different connotations throughout history, depending on the context in which it has been situated. In this paper we focus on one of these meanings, mainly the practical approach which proposes the analysis of a given subject by breaking it into smaller pieces in order to understand the whole by the properties of its parts (also known as reductionism, and usually opposed to the idea of holism, or conceiving the whole).

These concepts were some of the main foundations of the scientific revolution and influenced the western sciences for almost three centuries, bringing unforeseen development in several disciplines including mathematics, physics and astronomy. However, during the first half of the 20th century, in some fields of science the mechanistic view was no longer appropriate. The natural sciences moved towards a new way of thinking, proposing a shift from mechanistic to systemic thinking. Within this transition, ‘organicism’ in biology proposed a new way of understanding life and nature rejecting previous vitalism, reductionism and mechanism. According to Allen (2005), through ‘organicism’ biologists understood organisms as whole and complete entities, being the whole not just the sum of its parts, but rather the integrity of the relationships between these parts.

Pioneered by organicism, such movement was followed by different disciplines as Gestalt psychology, the new science of ecology and the quantum mechanics theory (Capra, 1996). These alternative approaches were the first steps towards what we know today as ‘systems theory’. In all these fields, scientists realized that the systems they studied had to be treated as wholes whose properties could no longer be reduced to smaller parts. Here we will only discuss the first two movements due to their relevance to current arts and design.

The development of Gestalt psychology played a significant role in the systems thinking history as it also supported the paradigm shift from the parts to the whole. First introduced in psychology by Christian von Ehrenfels, the concept of ‘gestalten’ is used to describe states and events whose properties and effects cannot be simply reduced to the sum its parts (Arnheim, 1998). Such a concept was recognized by Max Wertheimer in the 1920s while studying human behavior and perception, and reinforced by Kurk Koffka who formally added that “the central physical processes should be not viewed as sums of single stimulations but as wholes” (Arnheim, 1998). Gestalt psychology promoted the idea of holism mainly through the study of visual perception, and was fundamental for the general theories of perception which subsequently influenced design and creative disciplines.

Also in the beginning of the 20th century, another important development that enhanced the systems thinking movement was the rise of the science of ecology. Considered new at that time, the roots of ecology are historically diverse. According to Kingsland (2004), the idea of network was first introduced during

this period, expanding the concept of systems thinking from organisms to communities. (As will be discussed later, the science of ecology is very relevant for contemporary arts and design disciplines as it provides the basis for environmental awareness and sustainable development, important aspects of today's society).

It was not until the 1940s when the systems theory was formally proposed in line with Bertalanffy's concepts of 'open system' and 'general systems theory', consolidating systems thinking as a major scientific movement. Simultaneously, mathematicians, social scientists, neuroscientists and engineers were involved in the development of a new movement—the cybernetics. The word 'cybernetics' refers in science to the study of communication and control regarding machines and animals. According to Capra (1996), the cyberneticists were also concerned about networks and closed-loops which led them into the development of the new concepts of self-regulation and self-organization.

Another important fact that is worth highlighting is the rise of new mathematical theories during the 1970s. Chaos theory and fractal geometry, which have influenced arts and design for decades, emerged as powerful tools not only for mathematics studies, making it possible to describe and better comprehend complex systems networks, taking the systems theory to a whole new level.

Since the 1940s, systems thinking was largely incorporated into engineering and business administration, since it could be used to predict and solve practical problems. As will be discussed later, among diverse definitions design has been understood as a problem-solving discipline, and thus the use of systems thinking has become very important in contemporary design practice and education.

Systems thinking and disciplinarity in contemporary design

As discussed by design researchers since the beginning of the 1960s (Green, 1974; Archer, 1979; Jones, 1992; Margolin & Buchanan, 1995) we can perceive an historical evolution in the understanding of design. It has been considered an art, a science, a planning method, a problem-solving method and even a language. Furthermore, and strongly related to creativity in arts and design as discussed later in this paper, in "Designerly Ways of Knowing", Cross (2006) even proposes that design stands by its own as a field of knowledge different from the humanities and the sciences. He argues that humanities depend on literacy and their object of study is the human experience while sciences depend on numeracy and their object of study is the natural world. Different from the humanities and the sciences, 'design' is expressed through modelling and its objective is the creation of the artificial world.

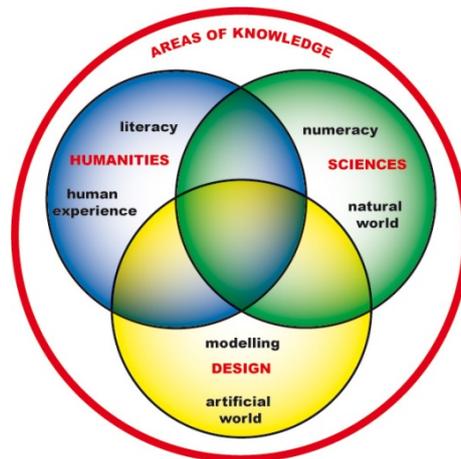


Figure 1. Design as a field of knowledge

Source: Adapted from Cross (2006)

In relation to systems thinking, Jones (1992, p. ix) proposes that:

alongside the old idea of design as the drawing of objects that are then to be built or manufactured there are many new ideas of what it is, all very different: designing as the process of devising not individual products but whole systems or environments such as airports, transportation, hypermarkets, educational curricula, broadcasting schedules, welfare schemes, banking systems, computer networks; design as participation, the involvement of the public in the decision-making process; design as creativity, which is supposed to be potentially present in everyone; design as an educational discipline that unites arts and science and perhaps can go further than either; and now the idea of designing without a product, as a process or way of living in itself.

We define ‘design’ as the planning and creation of an artificial (human-made) product (understanding by product a service, system, space or object), driven by problem-solving to fulfill human necessities (of utility, comfort, beauty, emotion and communication, among others). In summary and over-simplifying it, we could say that design as a human activity is mainly our conscious action to modify our environment and create the artificial world (Montana-Hoyos, 2010). Design affects our context at different levels. From micro to macro, we can define a local, regional, national and global context. (Figure 02, left image). Within this same logic, design disciplines are closely interrelated but operate at different levels of complexity and scale. In the smaller scale (hand-scale or human-scale), we classify design disciplines as product design, industrial design and fashion design. On a larger scale we classify interior design and architecture, and on an even larger scale community design and urban planning (Figure 02, right image).

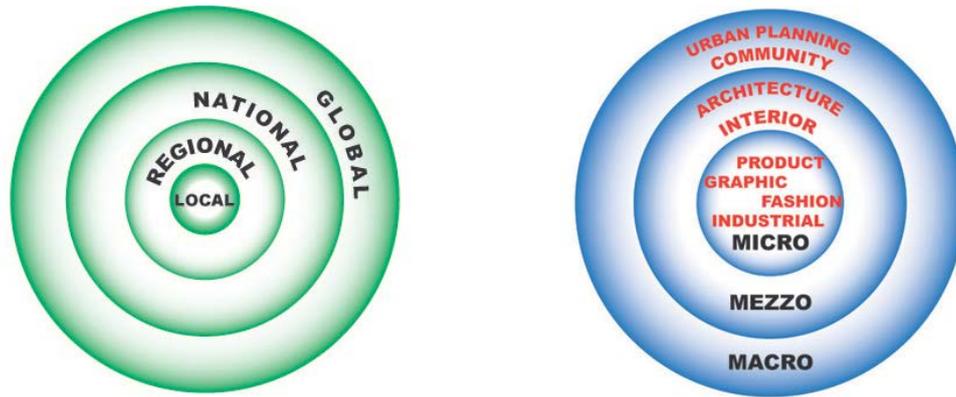


Figure 2. Diverse scales and complexities of context and design disciplines, as related to levels of disciplinarity

Source: Montana-Hoyos (2010)

Work across different disciplines is commonly and indiscriminately called crossdisciplinary, interdisciplinary or multidisciplinary. However, Nicolescu (1997), as cited by Marinova and McGrath (2004, p. 1) establishes different types of relationships between disciplines, proposing that:

Multidisciplinarity is defined as research that studies a topic not only in one discipline but in several at the same time. Interdisciplinarity concerns the links and the transfer of knowledge, methods, concepts and models from one discipline to another. Transdisciplinarity instead involves what is between the disciplines, across the disciplines and beyond the disciplines. Multidisciplinarity and interdisciplinarity remain within the framework of disciplinarity which is concerned with one level of reality, or fragments of that one level. Transdisciplinarity is interested in the dynamics of simultaneous action of several layers of reality.



Figure 3. Diverse scales and Levels of disciplinarity

Source: Adapted from Nicolescu (cited in Marinova & McGrath 2004)

In summary, design as an area of knowledge concerned with the creation of our artificial world currently relies on systems thinking to study, understand and propose adequate design solutions to problems at different scales. Although design practice and education are usually both multidisciplinary and interdisciplinary per se, an ideal approach to future design should transcend the barriers of the different

disciplines, aiming for transdisciplinary and holistic knowledge and practice which simultaneously understands and affects several layers of reality.

Creativity and critical thinking in design education

We have discussed in the previous sections some ideas about systems thinking and design and will now concentrate on education and creativity through some of the relationships among these topics. Within a general and discipline specific framework, we don't pretend to generate a new theory of creativity in design, but will mainly attempt to establish relationships, while reflecting upon how creativity might be affected by systems thinking, multidisciplinary and critical thinking within design education.

Many authors have extensively discussed the role and evolution of arts and design education. In general, education involves the growth and development of people. Through the transmission of knowledge and values and also by developing competencies, educators can strongly influence their students, hopefully helping them become better people or good professionals. Piaget (as quoted by Bleedorn, 2003, p. 12), proposes that:

The principal goal of education is to create men and women who are capable of doing new things, not simply of repeating what other generations have done...men and women who are creative, inventive discoverers. The second goal of education is to form minds which can be critical, can verify and not accept everything they are offered.

He proposes that the two main goals of education are creativity and critical thinking. Thinking is traditionally defined as the “ability to reason systematically with logic and evidence” (Adu-Febiri, 2002, p. 1). However, thinking encompasses multiple abilities that have to be simultaneously stimulated and developed, and thus this should be one of the goals of education. As expressed by Adu-Febiri (2002, p. 1): “Thinking is learned and can help people become original, creative, and innovative problem-solvers. However, many educational systems do not systematically develop thinking skills in students”.

Historically, many theories about the origins of creativity have been proposed, from being an accident with divine intervention (the muses of inspiration) to a creative process which can be developed and enhanced through adequate thinking tools, education and an environment that promotes thinking differently. Creativity is understood differently across disciplines. For example, in education it affects innovation, in business it becomes entrepreneurship, in mathematics it is problem-solving and in music it is performance and composition (Reid and Petocz, 2004). Most recent general works on creativity agree that multiple components must converge in a confluence for creativity to occur (Amabile, 1996; Csikszentmihalyi, 1999; Gruber & Wallace, 2001; Sternberg, 1999). Amabile defines creativity as the confluence of intrinsic motivation, domain-relevant abilities and creativity-relevant skills while both Gruber and Csikszentmihalyi use systems models in order to understand it. Sternberg, on the other hand proposes creativity as a decision-making process. As we will discuss later, several of these aspects are fundamental in design education.

Creativity appears to be the main aspect of the ‘creative disciplines’ related to arts and design, which deal precisely with the ideation and creation of the new artificial

world. While little research on the topic is claimed, some authors have recently studied creativity in the discipline of design (Cross, 1997a, 1997b; Durling, 2006; Lawson, 2004, 2006; Bonollo, 2010) whilst attempting to understand how professional and student designers know, think and learn.

Today creativity has acquired new meanings and importance. Successful companies such as Apple, Google, Facebook or IDEO are design-driven and have creativity and innovation—the implementation of creative ideas— (Von Stamm, 2008) as the key to their success. However, within the new challenges of global warming, environmental impact of human activities and sustainability issues of our ‘creations’, a new type of ‘inventiveness’ within the constraints of our finite resources is needed. As stated by Pink (2005), after the Information Age we are giving way to a new world in which qualities such as inventiveness, empathy and meaning predominate.

Within today’s context of ever-growing complexities, the link between creativity and critical thinking is thus worth exploring. As compiled by Mohanan (2003, p. 1)

critical thinking refers to a collection of overlapping mental activities of intuiting, clarifying, reflecting, connecting, inferring, judging, and so on. It brings these activities together to evaluate the credibility, quality, impact, significance, usefulness or desirability of an entity on the basis of an implicit or explicit value system and a set of criteria of evaluation. The entity being evaluated can be a knowledge claim, a research article, a work of art, a funding proposal, a social practice, an institution, a person, and so on, with the factors relevant for the evaluation varying accordingly.

In few words, critical thinking makes possible an effective evaluation of a situation or entity, which is related to analytical thinking for conscious and informed decision-making.

The process of design can be oversimplified as a ‘divergent-convergent’ iteration, where initially creativity promotes the generation of a very large pool of ideas (divergent phase), and then critical thinking aids in an adequate evaluation and decision-making for the selection and refinement of the most adequate ideas (convergent phase). Informed decision-making skills are nowadays important not only for designers, but also for artists, communicators and other members of the “emerging creative class” (Florida, 2002). This is due to the quantity and complexity of factors that affect decisions during our creative process, and mainly due to the ‘massive and immediate’ consequences of these decisions in regard to social, political, economic, environmental, and cultural factors, among others. With the ever-evolving massification, globalization and immediateness of contemporary creative production as well as the huge quantities of information we process daily through mass-media and the world wide web, today’s students of creative disciplines such as arts and design must be prepared to deal with increasingly complex issues of our society. Within a world where creative production is reproduced massively and instantly while being ‘blogged’, ‘YouTubed’ or communicated through ‘social networking’, and where positive or negative consequences can be global and immediate, a conscious and informed decision-making is more relevant than ever in relation to creativity in arts and design.

Case study: transport design education in UC-ID

Traditionally, transport design within Industrial Design (ID) courses has mainly focused on what is considered the ‘realm of industrial design’, which means the materialization of a tangible product, in terms of a vehicle, be it a motorcycle, car, train, etc. Usual considerations are mainly the interior and exterior design of these vehicles, through combination of aspects driven by aesthetics and marketing (such as car styling and colour design), as well as pragmatic aspects related to fields such as ergonomics, usability and user-centred design. Some examples of this are the master’s in transport design courses offered by Umea University in Sweden, Domus Academy in Italy or Istituto Europeo di Design, with branches all around Europe. In Australia, transport design courses which focus on systems design are usually found in Engineering courses, such as the one in Swinburne University, or as part of multidisciplinary research groups, as is the case of Monash University, where the Institute of Transport Studies has developed projects with the 3rd Year industrial design course (Allen, Coxon, & Napper, 2007).

Although this approach is still valid within the product design or transportation design education and professional practice, it is important to broaden the scope of industrial design, from the design of ‘products’ to the design of ‘systems and services’. This is in line with global trends in the evolution of ID, where design tends to digitalization and dematerialization and to problem-solving within a systems-thinking approach.

Industrial design is concerned with issues from micro (tools and appliances) to macro (systems) and cannot be practiced as a separated, isolated field anymore. Industrial design can be considered as a linking tool which binds different disciplines together in order to innovate and create our man-made world, simultaneously considering the latest consumer trends, political agendas, technological developments or communities’ concerns, among others. (Lemaitre & Montana-Hoyos, 2011, p. 2)

Within this context, the Industrial Design course of the University of Canberra (UC-ID) has developed for three consecutive years a transport design course focused on interdisciplinary and multidisciplinary collaborative projects to develop public transport solutions in collaboration with the land planning authority of the Australian Capital Territory (ACTpla).

The need to embrace an overall vision of broad issues and work on whole transport systems is the reason why the ID course at UC has committed to promote that the students work hand in hand with different protagonists representing other disciplines and competencies. The transport design project, not seen as an isolated ‘styling’ exercise (related merely to the form and appearance of a vehicle), is part of a broad reflection on systems design and user centred design, often including diverse parameters such as the integration of new technologies with design for sustainability tools, in order to improve people’s lives.

This case study is an example of creativity enhanced by systems thinking and collaborative interdisciplinary and multidisciplinary work. We will not describe in detail the planning and implementation of such a course as it is not relevant for the main argument of this paper, but will rather concentrate on the aspects of collaborative interdisciplinarity and systems thinking within the project, to reflect from a scholarly point of view on the importance of these aspects in contemporary arts and design education and practice.

The project usually included collaboration with diverse stakeholders, namely ACTpla (which for design students was equivalent to a client in a real world scenario) and in this case diverse design specialties, such as Landscape Architecture (LA), Architecture (Arch) and Industrial Design (ID). ACTpla proposed a real city planning project which they are currently still developing, which looks for public transport solutions for Canberra, namely connecting new suburban developments with the city Centre). This input was extremely beneficial as it showed the students that this project was of real concern to ACTPla and not just an academic assignment, which gave them a sense of ‘real achievement’.

In terms of the previously discussed aspects about creativity, we would argue that operating within ‘real-life constraints’ helps to promote it, rather than blocking it. Traditionally within the creative disciplines ‘real-life constraints’ are many times perceived negatively as ‘blocks’ to creative outputs, as opposed to more ‘free’, ‘experimental’ or ‘blue-sky’ approaches. However, ‘real-life constraints’ can also be a great external motivation, which can challenge and promote the designers’ ‘intrinsic creative motivation’, noted by most authors as a personality trait of creative people.

In relation to the diagrams presented in figure 2, the project usually operated at a local level. However, within an interdisciplinary and multidisciplinary approach, students shared and discussed diverse transport design concerns at different scales and levels, in iterative feedback loops which simultaneously considered large scale aspects (macro) as well as small details (micro). Multidisciplinarity was achieved as diverse disciplines and stakeholders studied the same topic (public transport in Canberra) through the specific knowledge of each discipline. ID students attended presentations by LA students. It showed them that, like in real life, people had to think about the site design before working on the design of the vehicle itself. LA students stressed some important elements such as emphasizing the beauty of the landscape on the way to the city or preserving existing native trees. ID students also worked with Arch students, who helped position and develop infrastructure elements such as rails and stations. While focusing on ID specific knowledge in the design of the vehicles, students also benefited from the input of other disciplines, gaining a better understanding of the different design considerations across different levels of the whole transport system.

Although complex and time-consuming in logistics and project management, further similar projects should include more relevant stakeholders. As examples, manufacturing industry could be involved, and furthermore the final-users should be involved in ‘participative’ and ‘user-centered’ design processes, related to ‘empathy’, an important characteristic of the new world as proposed by Pink (2005). Also, input and collaboration with other disciplines (not only design-related ones in this case study) such as ecology, sociology or arts, just to mention a few, would strengthen multidisciplinarity and interdisciplinarity, hopefully evolving towards a transdisciplinary and holistic approach.

In relation to systems thinking, while designing the vehicle ID students had to simultaneously consider other aspects of public transport systems, such as landscape, possible routes, scenery, alternative transport to public facilities and stations, frequency of travel, among other important considerations. In many cases awareness of these aspects enhanced (rather than blocked) creativity, giving more meaning to the design of the vehicle itself. For example, some vehicles and stations exploited the beauty of the scenery, incorporating the contemplation of the landscape as a main driver for the vehicle design.

In summary, the whole project was approached as an interdisciplinary and multidisciplinary collaboration, through a system-analysis and subsequent system-design focus. Its aim was to satisfy future transportation needs of ACT citizens, within a user-centred approach. Although the main ID project outcome was the proposal of the ‘vehicles’, they were conceptualized not only in relation to interior or exterior design, but mainly through considerations of infrastructure and land, as active part of a whole complex transportation system. This case study has helped us reflect on systems thinking, multi- and interdisciplinarity as fundamental elements to develop creativity in contemporary design education.

Conclusions

The literature review and reflection upon our own case study suggests that the development of creative and critical competencies which are fundamental and inherent to the diverse disciplines of arts and design are enhanced through integrative, collaborative, multi and interdisciplinary (and hopefully transdisciplinary) teaching-and-learning methods. Integrative and project-based education enhances the ability to make new connections and relationships, which is a fundamental component of creativity. This is further promoted by transdisciplinarity, through a broadening of the scope of knowledge among diverse disciplines, which also widens the scope of ideas and concepts that can be ‘recombined creatively’ within the divergent phase of the design process.

As cited by Von Stamm (2008, p. 8), in the report *The Creative Age* (Seltzer & Bentley, 1999) we can find that one of the most concise descriptions of highly creative people is that they “have the ability to: a) formulate new problems rather than depending on others to define them, and b) they have the ability to transfer what they learn across different contexts”. Creative and critical thinking are both fundamental in order to formulate and evaluate new problems, while interdisciplinarity and multidisciplinary facilitate the transfer of knowledge across contexts. Furthermore, creative and critical thinking skills can provide feedback to one another, becoming complementary and interdependent in an effective thinking process. In simple words, creativity, or a divergent thinking process, provides a wide variety of ideas and possibilities from which to choose a possible solution. Subsequently, critical thinking, or a convergent thinking process, provides the tools to effectively evaluate and choose the most suitable of the solutions generated in the creative process. This feedback loop of creative and critical thinking becomes then fundamental in the development of creative projects, and thus is essential in current arts and design education.

Systems thinking (also called systemic thinking) focuses on studying the relationships, links or interactions between the components of a system, rather than the components in isolation. As discussed previously, systems thinking theory proposes that every component within a complex system is inter-related to all other components. As such, as proposed by Milbrath (1966) and cited by Bleedorn (2003, p. 18),

systems thinkers focus on wholes, rather than on parts. Within wholes they concern themselves with relationships more than objects, with process more than structures, with networks more than hierarchies. In a system, a given effect not only radiates through the system, it also feeds back and changes the factor that caused it.

In relation to systems thinking, we can see in current research in design and design education a strong focus in integrative, collaborative and cross-disciplinary

pedagogies and project-based teaching, as opposed to specialized, fragmented and discipline-specific knowledge. Holistic thinking enhances and promotes integration, connections and relationships. This integration can be understood in diverse levels, such as: connection of knowledge or skills from diverse fields, sources or experiences; the exploration of diverse points of view from different stakeholders within a situation or context; and finally the integration of theory with practice. In summary, the main objective of holistic thinking is interconnectivity, or the creation of relationships and connections. Holistic thinking is closely related with systems thinking, and through the creation of new relationships and connections it can also enhance creativity.

A systems' thinking approach applied to the process of design requires a constant feedback between macro and micro scales, illustrated by analogy to an iterative zooming in and out from a picture. It is important to simultaneously and iteratively see the 'big picture' and understand the macro context, while at the same time understanding the relationships between the system and the small and fine details of all the parts and their components. This cycle of constant iteration from macro to micro can be visualized through two opposing spirals within a circular context, as illustrated in the three steps of figure 4.



Figure 4. Iterative cycles of micro-macro zooming in and out which can aid systems thinking in design.

Source: Montana-Hoyos (2010)

In summary, we would argue that the development of systems thinking, creative thinking and critical thinking competencies are fundamental in contemporary arts and design education, and crucial within the education of project-based design disciplines (such as Industrial Design). In terms of problem solving which is inherent to design (although not its only objective) systems thinking provides a broad understanding of a complex system through the study of the different relationships within its diverse components. This study of relationships rather than parts creates a good framework for creative thinking, enhancing the possibility of establishing new relationships. Finally, critical thinking skills provide a tool to effectively evaluate a situation, in order to choose the most adequate solutions which will affect positively the entire system, and not only a part of it. Tangible examples of this can be found in contemporary design education and a case study in transport design evidenced some of the aspects and relationships proposed in this paper.

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