the RADICAL DESIGNIST

Senses & Sensibility 2015 Special Issue | February 2016 Edition

USING VIRTUAL ENVIRONMENTS IN BASIC DESIGN EDUCATION

Ana Glória Neves, Emília Duarte

UNIDCOM, IADE – Creative University

ABSTRACT

The aim of this paper is to present a reflection about the potentiality and interest of Virtual Reality (VR) for innovation in the Basic Design education. Basic Design is about affording meaningful learning experiences to the newly arrived design students while introducing the design fundamentals. Without approaching real design problems, but abstract phenomena creation, Basic Design allows unique opportunity for self-expression and discovery. At a present course named 3D Design Lab, different construction principles provide combinatory training for generation and transformation of surfaces/ patterns, volumes and spaces, according to the transformative geometry. Abstract forms manually crafted at hand scale foster a methodology for structure complexity while developing an aesthetic-projective attitude. In this context, several challenges faced by the students, such as bonding with the abstract forms; imagining different possible applications for them in the real world; and others, can be overcome within the alliance with VR. This technology is also known for promoting a sense of presence that positively affects the designer in the creative process, improve spatial visualization and, in certain conditions, enhance students learning outcomes. As discussed further, VR might impact positively the teaching and learning experiences at the course, and hence, Basic Design. Consequently, we will present the origins, utility and main theoretical concepts of Basic Design and 3D Design Lab, as well as introduce VR, its main advantages and inconveniences. Finally, possible ways of using VR in Basic Design education are advanced, from a conceptual point of view, hoping to motivate the research community for further study this possibility.

Keywords: Basic Design; 3D Design Lab; Virtual Reality (VR) and Virtual Environments (VEs).

INTRODUCTION

Given the pressing social challenges and the profound changes required in all areas of activity, the designer, creator of interfaces that mediate everyday action, is increasingly requested. Recommendations were made to improve design literacy in Europe[1] providing every citizen with capabilities to transform tangible and/or intangible objects in each sector of life. Design is also known as being part of a set of senses that all individuals need to develop to overcome the conceptual age, along with Story, Symphony, Empathy, Play and Meaning[2].

Increasingly sooner familiar with the new digital technologies, the XXI century designers print a changing point into current teaching methodologies. The irreversibility and intensification of this phenomenon have driven the practice and evaluation of new learning environments and teaching methods. Also design education faces new challenges and opportunities, delivering new pedagogical approaches[3].

Basic Design, however, remains an unexplored field regarding the use and impact of new technologies in the teaching-learning process, specifically, Virtual Reality (VR), setting a venue for research. This exploratory study presents some evidences for eventual advantages and inconveniences of that partnership, while considering the case of a present course, 3D Design Lab. Rooted in Basic Design education, the discipline reaffirms the adequacy of the referred pedagogy in the present and future of design education, where the contribute of VR technology is a possible near scenario. The validation of this statement is the main goal of a research project conducted as part of a doctoral program that will provide possible means for assessing the impact of the VR technology: in overcoming some difficulties expressed by the first year design students under the present conditions; in the performance differentials and/or lead times; in the level of involvement/engagement in the task; and in the overall quality of user experience (UX).

BASIC DESIGN EDUCATION

At university design education programs, Basic Design is still a very important component[4]. It refers to the teaching and learning of design fundamentals, or the Principles of Two-and Three-dimensional Design[5]. Other authors prefer the term Design Patterns, as Bonsiepe[6], thereby overcoming the lack of consensus on the most widespread expression: Basic Design. We refer to the propedeutic training of projective disciplines, disseminated from the experience of the Bauhaus School (1919-33). Decisive moments in its evolution were also those perpetrated by Moholy-Nagy and Chermayeff, at the New Bauhaus, in Chicago (1937-55), and subsequently, by Max Bill, Otl Aicher and Tomás Maldonado, at Hochschule fur Gestaltung, in Ulm (1953-68).

Basic Design, as it is more commonly known, is the pedagogical model invented in Bauhaus to introduce students in the design fundamentals in a rational way whilst linking the related knowledge, attitudes and skills derived from the study of Basic Design to the pedagogy of design practice[7]. The journey develops more an attitude than a profession, built on the dichotomic pedagogical principle "intuition and method" or "subjective experience and objective recognition"[8]. Basic Design education is actually considered the effort of expressing the abilities and power of creativity in aesthetic level and transfer of thinking, emotions, and impressions of a person[9].

Some characteristic of that initial formative period of the designer are the aesthetic and formal exercises, exploration of color, composition and texture, in order to train the sensitivity for the aesthetical--projetual phenomenon, and where the technical and physical factors of the materials, ergonomics, costs, manufacturing processes and even the function, are not considered[10].

Design competencies are needed in a varied of fields and professions. According to the pedagogy spread by Moholy-Nagy, they should be developed through activities aimed at the ability to express the design elements (line, shape, color, space, movement, texture, volume) in various media, starting with tangible two-dimensional and three-dimensional (pen, pencil, paper, clay, wood); and then, intangible (light, space and sound). These explorations required the same kind of interaction with the world, the same perceptive-retinal-action used in everyday life. Findeli declares Basic Design the best pedagogic tool for developing visual intelligence in the present century. That skill allows the understanding and transformation of the invisible relations between the system's elements, in all its complexity[11].

Also Marcolli's pedagogy (1971), based on the perceptive types of E. Bullough, relegates to the current era a proposal for developing the visual perception for project activity in multiple fields of human action, including design. Such development takes place through four successive fields/spaces: geometric--intuitive; gestalt; topological; and phenomenological. They are implemented by the transformational geometry: Euclidean; affine and projective; topological; and set theory. Each field is, in turn, addressed according to its structure; the composition of objects; object-field interaction; and finally, tension and movement. The scientific literature is silent regarding Marcolli´s projetual pedagogy, a fact which may be due either to the unfamiliar language, as the high level of theoretical abstraction[12].

Knauer´s recent approach to the principles and methodology of design, called Transformations[13] is a great opportunity for clarifying the transformational processes constitutive of Basic Design pedagogy. According the author, practicing the true nature of design, the constant combinatory of elements (bar, surface and body), with the leading of aesthetics through abstract forms and a disinterest for function, may be introducing the individual to a design language. That language is developed by the individual's inner force of exploration and expression while mastering a medium. Deepening and amplifying the experiences from one medium empowers the co-generation of form and designers as integrators, as established in Moholy-Nagy´s pedagogy. He envisioned, through the one medium manual-perceptive intensive training and mastery, the capacity to understand/intuit the invisible interactions in every phenomenon of the world[14].

Looking in depth Knauer´s "Transformations", basis structures consist of formal processes that the imagination´s images can developed via not-yet-fixed structures that have not yet been to a conclusion, more easily and with fewer limitations, leading to surprising possibilities for design and reformulating[15]. Accordingly, basis structure consists of a methodologic binding preparation for the form-object complexes. Relating the abstract forms/basis/signifier (form empty of content) to semiotically finished objects citations/function/signified (form related to content), is the process by which the author refers to "assigning citations to basis". Knauer argues, in this sense, that the space of aesthetic cannot be expanded without fictional, emotional and sensory values, requiring for citations, possibilities for its semantic determination. Consequently, "assigning citations to basis" extends imagination by stimulating and motivating, in an intrinsic way, the search for a vocabulary, a morphological collection.

There is also a different approach to the introductory design course, more commonly used in architectural education, Virtual Design Studios (VDS). It address a rubric called problem-based learning — PBL, also found in other disciplines such as medicine, engineering and mathematics, among others, and it is largely focused on the idea of presenting students with a real design problem, for exploring solutions, experimenting failure, success and frustration along the way[16]. At 3D Design Lab, as in Basic Design education, there are no real problems to be addressed, but opportunities for incorporating, by doing, the principles that underlie the creative process embedded in the prospective act, that is, project.

EXTENDING BASIC DESIGN TRADITION AT 3D DESIGN LAB

Implemented internationally, Basic Design pedagogy has been adapted to the present times[17]. Grounded on the Basic Design pedagogy, the methodology currently adopted in Laboratório de Design 3D (3D Design Lab), was revised and updated by Fernandes[18]. With a broad frame of reference, 3D

Design Lab stresses the Italian influence of Bruno Munari[19], Attilio Marcolli[20] and Tomas Maldonado[21], since the foundation of Instituto de Artes Visuais, Design e Marketing – IADE, at 1969, pioneering design teaching in Portugal. Recent school options for the discipline align with the theory-methodology of Gui Bonsiepe[22] and the proposals of Roland Knauer´s transformations[23], in convergence with Steadman´s[24] latest compositional techniques, closely relating the nature and human action[25].

The course is taught at Instituto de Arte, Design e Empresa – Universitário – IADE-U, to the first year design students, also known as emergent adults, individuals between the ages of 18 and 24 that are living ages of: identity explorations; instability; self-focused; feeling in-between, in transition, neither adolescent nor adult; and an unparalleled opportunity to transform their lives[26].

The structure of the course

3D Design Lab corresponds to a cross propedeutic training to the three main project areas: visual; industrial; and environments. It aims the incorporation of an investigation method for generating complex systems in parts-totalities-parts, by recursively applying trial and error while provide student engagement in creation / construction of three-dimensional, hand scale, abstract forms, mainly using the hands. The perceptive-retinal-manipulative acts aim the dynamic and transformative nature of space-3D shapes, encourages the release of the mind of pre-established phenomena, and the discovery and reinvention of reality and the individual. Functional aspects of the objects are not taken in consideration, as well as most components of a design project. Are also excluded some of the elements of design usually considered in a Basic Design course, like color and texture. The course focus on developing a sensitivity to the technological and aesthetic phenomena and projetual ability[27] over the incorporation of design patterns: field structure; reference mark; elementary part; elementary motif; combinatory; modularity; patterning; symmetry / asymmetry; formal coherence; structural consistency; systemic; complexity; simplicity; maximum diversity with the minimum repertoire; among others. These concepts are repeated throughout the three exercises, moments that reveal the influence of the four perceptive fields defined at Marcolli's projetual pedagogy[28].

The exercises at 3D Design Lab consist of activities triggered by minimum action programs, of departure[29]. Each sequence of actions will conform the object in which it is clear, in a "before and after", the emerged impasses during the process, and the overcoming those difficulties. The regular comments and criticisms to the students work are decisive for the adequate change, and therefore, an essential dialogue for learning and development. In a close orientation with each student, the teacher uses whatever examples and explanations he/she considers adequate for the overcoming the impasses. This unblocking can be considered an important pedagogic instrument, making use of verbally transmitted

www.iade.pt/unidcom/radicaldesignist | ISSN 1646-5288

cues, resembling Knauer´s “citations”[30]. The principles and concepts are also introduced in the dialogue with students about what is being done rather than being previously exposed. Also, no visual examples are provided, avoiding the natural tendency of novices to rush to obvious results, frequently objects semiotically recognized from the daily life, a fact also reported by Munari[31]. Breaking that attitude with abstract examples is also a common strategy for developing a proper understanding of the creation and transformation process, traditionally used at Basic Design education. According Fernandes methodology, no specific competence is required for the exercises, allowing any supposed unprepared student to overcome difficulties, as they arrive, closely supported by the teacher´s feedback. Incorporating the configuration process starts with an operative knowledge and directs itself, through an aesthetic feeling, to a reflective knowledge materialized in a totality/configuration/object.

The traditional learning by doing process is perfectly aligned to Knauer´s operative aesthetic[32] where the search of the form is leaded, not by the function of any semiotically finished object, but by a constantly increasing of aesthetics, on an abstract form empty of content. In that sense, an increasing growth of complexity within the 3 moments/exercises is provided by: the application of successive levels of perception of space suggested by Marcolli[33]; the approaching of 2D before 3D[34]; and the creation from parts to totalities, in the first and second exercises, to the last one, where the totality of the form is first explored and then, the methodological process determines its constitutive elements. The evaluation of the exercises reflects this increasing of complexity, each one assessed in three categories of competences, with precedency: technique, analytic and aesthetic.

An engaging component is the reaching of the quality in the visual effects, when recognized by the student´s themselves and their peers, referring them as interesting, beautiful, and so on. The judgment and criticism of own work and the others is rooted on technical quality and brought by an intense effort to master the manual process. At the end of each exercise is requested visual analysis of the whole process, which takes place by means of a test, in the 1st exercise, and posters and/or videos, in the 2nd and 3rd remaining exercises. Once finished, are exposed and commented, by all.

VIRTUAL REALITY AND VIRTUAL ENVIRONMENTS

VR is a 3-D artificial environment that allows the users to live artificial phenomenon with the intensity once thought to be unique of real life. What makes it possible is the feeling of being indeed somewhere interacting with the objects presented, intuitively and in real time.

Virtual Reality (VR) is distinguished from other systems using Virtual Environments (VEs) and is characterized, according to the Triangle of RV proposed by Burdea and Coiffet[35] by enhancing the interaction, immersion and imagination, resulting in different levels of presence. The interaction corresponds to the degree of response of the virtual world and all it contains, in real time to user actions and can display realistic or unrealistic behavior. Immersion has to do with the real world isolation level offered by the system and can be more or less immersive systems. Imagination is a variable that depends exclusively on the participant and his willingness to be “deceived”. These factors, along with the degree of intrusion and discomfort caused by the devices (e.g., nausea, eyestrain, proficiency with navigation techniques) will result in a variable degree of presence, which aims to be high. The presence can be defined as a convincing sense of presence, in fact, in the virtual world, indicating loss of consciousness that the body remains physically in the real world. When compared with other systems using EVs, the VR systems allow the evaluation of more advanced aspects of interaction with the world, as behaviours or emotions with good ecological validity[36]. To assess perceptions such as space, shape, size, and other, EVs may be sufficient, being the example, environment or objects created 3D modeling software (e.g., 3D Studio Max; SketchUp Pro).

VR technology is currently used in a broad range of applications, such as games, movies, simulations, and a few main focus are training, education, collaborative work, therapy and learning (Lanyi 2012). The technology allow the generation of phenomena, alternative experiences to reality, enabling some of today’s most innovative pedagogical approaches[37], however, much of its potential is yet to unveil[38].

VR in the educational setting

It is presently reinforced the growing importance of VR in the learning context, where it facilitates learning abstract concepts, observation of phenomena at different scales, participation in events so far impossible to witness either for reasons of safety, costs, or distance[39]. Other recent study outlined the effectiveness of virtual reality technology-based instruction (i.e. games, simulation, virtual worlds) in improving learning outcome gains[40], reinforcing the already known positive affect of VR-based learning environments on the cognitive and affective domains of learners[41].

Games and Gamification are emergent technologies largely impacting world education, allowing strategies that stimulate collaborative work, creativity and motivation in students and teachers[42]. As highlighted in the NMC Horizon Report: 2014 Higher Education Edition[43], in two to three years, those technologies are to be adopted in the high educational context, for educational gameplay has proven to foster engagement in critical thinking, creative problem-solving, and teamwork, skills that lead to solutions for complex social and environmental dilemmas[44]. According to a recent study in Portugal, students from all cycles of education levels are players, from which, 94.7% male and 77.4% female students are from the secondary level[45]. Most of these game player students are now, or are going to be, entering the tertiary education.

Using 3D Virtual Environments for learning enable tasks that lead to improvement of spatial representation; more opportunities to learn from experience; increase motivation / interplay; enhance the context of learning; and enrich collaborative learning compared to 2D alternatives[46]. In the educational setting, VR allows observation from multiple perspectives, which encourages diverse ways of thinking[47] and it can be used to promote the transfer of learning[48].

An exploratory study within the Virtual Reality for Kids interested in Design Studies (VR-KiDS) evaluated design skills of children between the ages of 11 and 16 before and after an activity using Virtual Reality[49]. It showed that VR interface considerably increased logical, kinesthetic and naturalist skills, negatively affected verbal and intrapersonal skills and had no effect on spatial and interpersonal skills. Also VR interface was useful for less skilful students[50].

ANTECIPATING AN ALLIANCE BETWEEN VR AND BASIC DESIGN

Our pedagogical approach at 3D Design Lab, although supported by the traditional Basic Design education, is faced with the announced inevitability of VR presence in the future of design education[51] and its positive impact in the educational context. However, much work has to be done in order to evidence the qualities of the partnership between VR and Basic Design and consequently, research is mandatory. VR technology can reveal to us not only a new means of expression in basic design (innovation in terms of content), but also, effective procedures for human development (innovation in pedagogic level). Some possible contributions of VR for 3D Design Lab can now be deducted and conceptually formulated.

A profound investigation concluded that remains essential for design students to develop perceptual motor skills such as manual modelling and manipulation of materials, despite the advance and common application of computer based design tools[52]. Sorby[53] highlights, in this respect, the benefit of the manual-visual articulation for the spatial visualization, an essential competence for designers that VR systems can amplify[54]. Though advocated the use of computers to design 2D, Wucius Wong[55] considers that three-dimensional shapes are better understood in real space, "*in which all the dimensions necessary for the understanding of the ideas mass, depth and area of flow, as well as the nature of the various materials is provided*".

At 3D Design Lab, as already mentioned, the teacher orients the explorations undertaken by each student, observing emotions and actions, prompting immediate feedback, for what explanations and/or citations are used verbally. In between metaphors and analogies, citations are cues that work for unblocking difficulties, triggering actions and possible solutions for the problems faced by the students, leading them in his/her way out. As known, metaphors increase the activity in the design process, advancing new understanding and new actions, according the experience and personality of each student, besides assisting to grasp abstract concepts[56]. We are also familiarized with the effect of analogies on design activity, a cognitive strategy that largely benefit novices, rather than experts and leads to better understand abstract concepts, besides retrieving and implementing previously acquired knowledge[57]. Analogies are also recognized for alleviating fixation, a consequence of using physical prototyping[58] for which the author advances a proposal for using digital modelling using Augmented Reality[59].

The referred verbal citations link the abstract models to any known real situation: specific objects, forms, functions, daily life scenarios, revealing a powerful instrument for the teaching and learning at 3D Design Lab. Within this context, a common task to all three exercises, in different phases, could benefit from the use of VR. The abstract objects appear themselves to the students, at first, as strange foreign entities with which they are not identified. Gradually, the interest and motivation increases as experiences move on, sometimes set off by verbal suggestions of "what it could be", providing the emotional impulse to act-reflect in a recursive way. The imagination is then released and the search for new and interesting results signals a good learning outcome. However, that kind of approach is not effective for all students, with a few persisting in a disengaged and careless attitude. Also, others declare a personal missing enthusiasm for manual tasks, excusing their low performance. In this situation, setting a new environment, like VR, can be benefic, for what is known, different environments provoke distinct cognitive action types[60] reaching out also other learning styles. Perceptive-manipulative experience in a 3D virtual environment like VR could benefit the learning process at 3D Design Lab, as it may trigger emotions and actions in a more effective way for students presenting more difficulties within the traditional process. According to Lee[61] different learning styles not only impact interaction experience (e.g. how easily the user can interact with the system) but also learning experience (e.g. motivation)[62].

A protocol analysis experiment conducted with expert designers revealed that in digital design environments perceptual actions seem to be more frequent than in traditional real environments, as the previous condition provide a platform for designers to easily focus on the visual analysis of the design solution, probably due the simple way of control navigation and camera views, as well as the relatively realistic appearance of the design model[63]. Therefore, we deduce that VR technology could afford the opportunities to engage more students in the perceptual actions, for the lack of the referred cognitive dimension can be negatively affecting motivation, enthusiasm and eventually, performance results.

Being able to foresee multiple different scenarios and/or concrete applications for the abstract objects is essential for developing more complex and interesting forms, as part of Knauer's operative aesthetic methodology[64]. Complementing verbal citations with visual-manipulative ones, in real and virtual environments, could set the necessary impulse to act in some more effective ways. Abstract design principles, the main focus of Basic Design education, can be extended to different scenarios and contexts (real or imagined). VEs could amplify the concepts understanding to a bigger audience, especially to those having more difficulties succeeding in performing some of the tasks usually accomplished in the traditional way, besides reinforcing them to all students. Affording a virtual space for manipulation of owns abstract forms in some simple aspects could be beneficial for effective learning, engagement and learning experiences.

The designer as provocative of emotions and actions[65] can benefit from VR, through experiences applying the perception of their own emotions and those of others, at different levels of immersion and different situations/scenarios. Providing multiple and varied experiences by allowing easy manipulation, in terms of core operations, i.e., symmetry operations, can foster a higher engagement and better learning.

Adopting ergonomic terminology in product design, a scenario incorporates a context of use of a product (e.g., school, hospital, transport, industrial, agricultural) and a set of tasks that one or more users perform or intend to carry[66]. Thus, exposure to different scenarios will allow potential users present their ideas and/or questions about your interaction with the concepts of a product, in existing or future contexts. These scenarios can be used in various stages of development of a product and can serve to understand their features, develop attributes of a product or assess user behavior in critical situations interaction with a product or system. We can use different media to implement these scenarios; e.g., narratives written with or without illustrations; video narratives; drama with real characters or interactive virtual environments.

Quasi-experiments are frequently adopted in educational setting, with no random selection of participants[67], as conducted in the LiFE 1 project. Quasi-experimental methodology was used to determine the most effective type of 3D experiences on pupil learning and achievement and measured the value and impact of these experiences. Students were tested and measured before and after the lessons, with a “control” group learning in 2D only, and the other group receiving the same instruction plus 3D[68]. Also Merchant, Goetz, Cifuentes, Keeney-Kennicutt, & Davis[69] performed experimental or quasi-experimental research designs to evaluate the effects of the virtual reality-based instruction on K-12 and higher education settings, and used a learning outcome measure. Accordingly, this methodology could be helpful to determine the impact of integrating VR technology in Basic Design education. This quantitative methodology requires a pre-post design for cognitive and performance evaluation, for which the dependent variables can be: conception time; complexity (number of parts of the elements and motifs); quality of the proposal. Also important are the variables related with the quality of the experience and the engagement in the learning experience, related with the sense of presence of the student in the experience, such as: interaction; immersion of the system; and imagination.

CONCLUSION

Despite the permanently reaffirmed relevance and timelessness of the pedagogical model initially called *Vorkurs*, Basic Design seems to resist the advances of digital technologies, namely, Virtual Reality. For Findeli[70], the pedagogic approach stated a hundred years ago, persist on showing it´s adequacy in the present century[71]. It´s pillars being the interactions, and with it, the properties of the systems generated and transformed, in all human areas, the investment should continue to be done in the leading part of those actions: emotions. Those are what determine each of our acts, and therefore, all activities we engage. Supporting 3D Design Lab is Knauer´s operative aesthetic, a methodology for conducting a personal language out of an abstract elementary unity form that always asks for citations, connections to the senses and emotions. In order to keep the pace in the present era, with all the new ways of interacting and learning the new generation is increasingly familiarized with, we should provide them the opportunity to learn the Basics of Design accordingly. It requires, in line with the pedagogy of design, manipulating the invisible interactions in such a way that evokes spontaneity and intuition for them. Those ways are now set out in the virtual space, the new familiar environments from the new era that is showing to be effective for engagement and motivation, and learning, under the right conditions.

The features of the new technologic mediums, namely, VR, offer great opportunities for trying safely and with lesser costs, tasks otherwise impossible in the traditional setting. The models created by hand, in each of the three exercises, once transposed into digital format, e.g., using simple 3D modeling software, can be experienced in an infinite ways, at different scales, benefiting all areas of design, especially interior/environment design. Feeling their own creations as real life objects could work as an upgrade to the traditional verbal “citations” that never seem to result for all. Subsequently, bonds with students own creations could open up a world of possibilities for co-transformation of objects and themselves, and in this sense, the new alliance could contribute to overcome moments of anxiety, easily open the way to self-expression and to a new dimension of emotion discovery. By adding the new medium, new elements could be introduced like colour, texture, light, movement and music, so that more complexity and expressive potential could be added. Also different points of view, distances and scales could benefit perception skills, visualization and imagery imagination, prompting creativity.

Therefore, investing in VEs, and specifically, VR, can turn some light to the problem of introducing the future generations in the creative activity, that is, design. We hope this study had sparked the debate about the craft of new kind of meaningful teaching and learning experiences in Basic Design education.

Notes:

1
EDLB, Design for Growth and Prosperity, 2012.

2
PINK, Daniel. H. *A Whole New Mind: Why Right-Brainers Will Rule the Future,* 2006.

3
GU, Ning, GUL, Leman F., WILLIAMS, Anthony, «Methods for evaluating 3D Virtual Worlds in Design Education», 2010, pp. 1259 - 66.

4
BOUCHARENC, Christian, «Research on Basic Design Education: An International Survey», 2006, p. 18.

5
Idem, p. 1.

6
BONSIEPE, Gui, «The Uneasy Relationship between Design and Design Research», 2007, p. 34.

7
op. cit. BOUCHARENC.

8
DROSTE, Magdalena, *Bauhaus*, 1992.

9
BESGEN, Asu, KULOGLU, Nilgun and FATHALIZADEHALEMDARI, Sara, «Teaching/Learning Strategies Through Art: Art and Basic Design Education», 2015, pp. 428 - 32.

10
op. cit., BONSIEPE, 2012, p. 74.

11
FINDELI, Alain, «Rethinking Design Education for the 21st Century: Theoretical, Methodological, and Ethical Discussion», 2001, p. 14.

12
FEDERLE, Giovanni, «Basic Design La formazione al design nella Scuola Secondaria», 2009, p. 22.

13
KNAUER, Roland, *Transformation. Basic Principles and Methodology of Design*, 2008.

14
op. cit. FINDELI, 1990, pp. 4 - 19.

15
op. cit. KNAUER, p. vi.

16
KVAN, Thomas, «The pedagogy of virtual design studios», 2001, pp. 345 - 53.

17
CETINKAYA, Cigdem, «Basic Design Education Parameters in Turkey», 2014, pp. 31 - 46.

18
FERNANDES, Rosa, «Design, Informação e Desenvolvimento: um contributo metodológico para a exploração do "Potencial Informativo do Produto" como fator de percursos de rápida "mudança emergente" orientada para o desenvolvimento», 2011.

19
MUNARI, Bruno, *Arista e Designer*, 1979.

20
MARCOLLI, Attilio, *Teoria del Campo*, 1998; 1991.

21
MALDONADO, Tomás, «O corpo humano e o conhecimento digital», 2012, pp. 119-150; 1981.

22
op. cit. BONSIEPE, 2012; 1992; 1999.

23
op. cit. KNAUER.

24
STEADMAN, Philip, *The Evolution of Designs: Biological Analogy in Architecture and the Applied Arts*, 2008.

25
op. cit., FERNANDES, 2013.

26
ARNETT, Jeffrey Jensen, *Emerging Adulthood: The Winding Road from the Late Teens through the Twenties*, 2004, p. 8.

27
op. cit. BONSIEPE, 2012, p.77.

28
op. cit. MARCOLLI, 1998; 1991.

29
op. cit. FERNANDES, 2011.

30
op. cit. KNAUER.

31
op. cit. MUNARI, 1995.

32
op. cit. KNAUER. p. vi.

33
op. cit. MARCOLLI, 1971.

34
op. cit. BONSIEPE, 1992; WONG, Wucius, 1995.

35
BURDEA, Grigore C., COIFFET, Philippe, *Virtual Reality Technology*, 2003.

www.iade.pt/unidcom/radicaldesignist | ISSN 1646-5288

36

REBELO, Francisco, et al., «Virtual Reality in Consumer Product Design: Methods and Applications», 2011, pp. 381 - 402.

37

SCHANK, Roger, *Teaching Minds: How Cognitive Science Can Save Our Schools*, 2011.

38

JONES, Derek, «An Alternative (to) Reality» 2013, pp. 1 - 20.

39

ABDELAZIZ, Marwa, RIAD, Alaa and SENOUSY, M. Badr, «Challenges and Issues in Building Virtual Reality-Based e-Learning System», 2014, pp. 320 - 28.

40

MERCHANT, Zahira, et al., «Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis», 2014, pp. 29 - 40.

41

LEE, Elinda Ai Lim, *An Investigation into the Effectiveness of Virtual Reality-Based Learning*, 2011.

42

MONTEIRO, Ricardo, BARBOSA, Helena, «Challenges Game: um jogo dinamizador do processo de ensino», 2014, pp. 74 - 84.

43

JOHNSON, L. et all., *MC Horizon Report — 2014 Higher Education Edition*, 2014.

44

Idem, p. 42

45

CARVALHO, Ana Amélia, et all., «Os jogos mais jogados pelos alunos do Ensino Básico ao Ensino Superior», 2014, pp. 74-84.

46

DALGARNO, Barney and LEE, Mark, «What are the learning affordances of 3-D virtual envi-ronments?», 2010, pp. 10 - 32.

47

op. cit. LEE, 2011, p. 2.

48

BOSSARD, Cyril, et al., «Transfer of Learning in Virtual Environments: A New Challenge?», 2008, pp. 151 - 61.

49

D'SOUZA, Newton, YOON, So-Yeon and ISLAM, Zahidul, «Understanding design skills of the Generation Y: An exploration through the VR-KiDS project», 2011, pp. 180-209.

50

Idem

51

COLUCCI, Katia, «What role will technology play in the future of design education», 2011, pp. 63 – 67.

52

op. cit. BOUCHARENC, p. 18.

53

SORBY, Sheryl A., «Developing 3-D Spatial Visualization Skills», 1999, pp. 21-33.

54

SIK LÁNYI, Cecília, et al., «Using Virtual Reality to Improve Space and Depth Perception», 2003, p. 293.

55

op. cit. WONG, p. 239.

56

COYNE, Richard, et al., «Metaphors in the Design Studio», 1994, pp. 113 - 25.

57

CASAKIN, Hernan, GOLDSCHMIDT, Gabriela, «Expertise and the use of visual analogy: implications for design education», 1999, pp. 153 - 75.

58

CHANDRASEKERA, Tilanka, «Using Augmented Reality Prototypes in Design Education», 2014, 33 - 42.

59

Idem.

60

GUL, Leman F., «Studying the Impact of Immersion on Design Cognition», 2009, p. 615.

61

op. cit. LEE, p. 44.

62

Idem.

63

op. cit. GUL, p. 621.

64

op. cit. KNAUER, p. viii.

65

op. cit. BONSIEPE, 2011, p. 53.

66

FULTON SURI, Jane and MARSH, Matthew, «Scenario building as an ergonomics method in consumer product design». 2000, pp. 151 - 57; NARDI, Bonnie A., «The use of scenarios in design», pp. 13 - 14, 1992.

67

CRESWELL, John, *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches,* 2013.

68

BAMFORD, Anne, «LiFE: Learning in Future Education Evaluation of innovation in learning using emerging technologies», 2011.

69

MERCHANT, Zahira, et al., «Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis», 2014, pp. 29 - 40.

70
op. cit. FINDELI, 1990, p. 18.

71
op. cit. FINDELI, 2001, p. 14.

REFERENCES

ABDELAZIZ, Marwa, RIAD, Alaa and SENOUSY, M. Badr. (2014). «Challenges and Issues in Building Virtual Reality-Based e-Learning System». *International Journal of e-Education, e-Business, e-Management and e-Learning* 4 (4): 320–28.

ARNETT, Jeffrey Jensen. (2004). *Emerging Adulthood: The Winding Road from the Late Teens through the Twenties*. 1 edition. New York; Oxford: Oxford University Press.

BAMFORD, Anne. (2011). «LiFE: Learning in Future Education Evaluation of innovation in learning using emerging technologies». Project.

BESGEN, Asu, KULOGLU, Nilgun and FATHALIZADEHALEMDARI, Sara. (2015). «Teaching/Learning Strategies Through Art: Art and Basic Design Education». *Procedia - Social and Behavioral Sciences*, 4th WORLD CONFERENCE on EDUCATIONAL TECHNOLOGY RESEARCHES (WCETR-2014), 182 (Maio): 428–32. doi:10.1016/j.sbspro.2015.04.813.

BONSIEPE, Gui. (1975). *Teoria e prática do design industrial: elementos para um manual crítico*. 1992 - 1ª ed portuguesa. Lisboa: Centro Português de Design.

_________(1999). *Del Objeto a la Interfase*. Buenos Aires, Argentina: Ediciones Infinito.

_________(2007). The Uneasy Relationship between Design and Design Research. In *Design Research Now: Essays and Selected Papers*, ed: Ralf Michel, 25–39. Germany: Birkhäuser Ar-chitecture.

_________(2011). *Design, Cultura e Sociedade*. São Paulo, Brasil: Edgard Blucher.

_________(2012). *Design como Prática de Projeto.* Brasil, S. Paulo: Edgard Blucher.

BOSSARD, Cyril, et al. (2008). «Transfer of Learning in Virtual Environments: A New Challen-ge?» *Virtual Reality* 12 (3): 151–61. doi:10.1007/s10055-008-0093-y.

BOUCHARENC, Christian. (2006). «Research on Basic Design Education: An International Survey». *International Journal of Technology and Design Education* 16 (1): 1–30. doi:10.1007/s10798-005-2110-8.

BURDEA, Grigore C. and COIFFET, Philippe. (2003). *Virtual Reality Technology*. 2 edition. Hoboken, N.J: Wiley-IEEE Press.

CARVALHO, Ana Amélia, et all. (2014). «Os jogos mais jogados pelos alunos do Ensino Básico ao Ensino Superior». Em *Atas do 2º Encontro sobre Jogos e Mobile Learning*, editado por A. Carvalho, S. Cruz, C. Marques, A. Moura, e I. Santos, 74–84. Universidade do Minho. Instituto de Educação. Centro de Investigação em Educação (CIEd).

CASAKIN, Hernan and GOLDSCHMIDT, Gabriela. (1999). «Expertise and the use of visual analogy: implications for design education». *Design Studies* 20 (2): 153–75.

CETINKAYA, Cigdem. (2014). «Basic Design Education Parameters in Turkey». Em *Humanitas International Journal of Social Sciences*, 31–46. Central and Eastern European Online Library.

CHANDRASEKERA, Tilanka. (2014). «Using Augmented Reality Prototypes in Design Education». *Design and Technology Education: An International Journal* 19 (3): 33-42. https://ojs.lboro.ac.uk/ojs/index.php/DATE/article/view/1971.

COLUCCI, Katia. (2011). «What role will technology play in the future of design education». Em *Icograda Design Education Manifesto 2011*, 63–67. http://toolkit.icograda.org/database/rte/files/PR_IEN_Manifesto2011_webres.pdf.

COYNE, Richard, SNODGRASS, Adrian and MARTIN, David. (1994). «Metaphors in the Design Studio». *Journal of Architectural Education (1984-)* 48 (2): 113–25. doi:10.2307/1425318.

CRESWELL, John W. (2013). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches,* 4th edition. Thousand Oaks: SAGE Publications, Inc.

DALGARNO, Barney and LEE, Mark. (2010). «What are the learning affordances of 3-D virtual environments?» *British Journal of Educational Technology* 41 (1): 10–32.

DROSTE, Magdalena. (1992). *Bauhaus 1919-1933*. Alemanha: Taschen.

D'SOUZA, Newton, YOON, So-Yeon and ISLAM, Zahidul. (2011). «Understanding design skills of the Generation Y: An exploration through the VR-KiDS project». *Design Studies* 32 (2): 180–209. doi:10.1016/j.destud.2010.07.002.

EDLB. (2012). «Design for Growth and Prosperity». http://www.beda.org/resources/other-publications/design-for-growth-and-prosperity.html.

FEDERLE, Giovanni. (2009). «Basic Design La formazione al design nella Scuola secondaria». PhD, Venezia, Italia: Università Ca' Foscari Venezia. http://dspace.unive.it/bitstream/handle/10579/1016/Tesi_Federle_2010.pdf?sequence=1.

FERNANDES, Rosa. (2013). «Programa da UC Design Tridimensional».

_________(2011). «Design, Informação e Desenvolvimento: um contributo metodológico para a exploração do "Potencial Informativo do Produto" como fator de percursos de rápida "mudança emergente" orientada para o desenvolvimento.» Madrid: Universidade Complutense de Madrid. Http://eprints.ucm.es/12198/1/T32379.pdf.

FINDELI, Alain. (1990). «Moholy-Nagy's Design Pedagogy in Chicago (1937-46)». *Design Issues* 7 (1): 419. doi:10.2307/1511466.

_________(2001). «Rethinking Design Education for the 21st Century: Theoretical, Methodological, and Ethical Discussion». *Design Issues* 17 (1): 5–17. doi:10.1162/07479360152103796.

FULTON SURI, Jane and MARSH, Matthew. (2000). «Scenario building as an ergonomics method in consumer product design». *Applied Ergonomics* 31 (2): 151–57. doi:10.1016/S0003-6870(99)00035-6.

GUL, Leman F. (2009). «Studying the Impact of Immersion on Design Cognition». Em *Computation: The New Realm of Architectural Design: 27th eCAADe Conference Proceedings*, 615–22. Istanbul Technical University, Faculty of Architecture.

GU, Ning, GUL, Leman F., WILLIAMS, Anthony. (2010). «Methods for evaluating 3D Virtual Worlds in Design Education». Em *International Design Conference - Design 2010*, 1259–66. Dubrovnik - Croatia.

JOHNSON, L. et all. (2014). «MC Horizon Report - 2014 Higher Education Edition». Austin, Texas. http://www.nmc.org/pdf/2014-nmc-horizon-report-he-EN.pdf.

JONES, Derek. (2013). «An Alternative (to) Reality». In *Understanding Learning in Virtual Worlds*, eds: Mark Childs e Anna Peachey. 1-20. New York: Springer.

KNAUER, Roland. (2008). *Transformation. Basic Principles and Methodology of Design*. 1.ª ed. Birkhäuser GmbH.

KVAN, Thomas. (2001). «The pedagogy of virtual design studios». *Automation in Construction*, CAADRIA, 10 (3): 345–53. doi:10.1016/S0926-5805(00)00051-0.

LEE, Elinda Ai Lim. (2011). «An Investigation into the Effectiveness of Virtual Reality-Based Learning». Phd, Murdoch University. http://researchrepository.murdoch.edu.au/4070/.

MALDONADO, Tomás. 1981. *El Diseño Industrial Reconsiderado*. Barcelona: Gustavo Gili.

_________(2012). «O corpo humano e o conhecimento digital». In *Cultura, Sociedade e Técnica,* pp. 119-150. Edgard Blucher.

MARCOLLI, Attilio. (1971). *Teoria del Campo - corso di educazione alla visione*. 1998.ª, 17ªed ed. Milano: Sansoni Editore.

_________(1978). *Teoria del Campo 2 - corso di metodologia dalla visione*. 1991, 3ª ed. Itália, Firenze: Sansoni Editore.

MERCHANT, Zahira, et al. (2014). «Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis». *Computers & Education* 70 (Janeiro): 29–40. doi: 10.1016/j.compedu.2013.07.033.

MONTEIRO, Ricardo and BARBOSA, Helena. (2014). «Challenges Game: um jogo dinamizador do processo de ensino». In *Atas do 2º Encontro sobre Jogos e Mobile Learning*, eds: Carvalho, A.A. et al, 74–84. Universidade do Minho. Instituto de Educação. Centro de Investigação em Educação (CIEd).

MUNARI, Bruno. (1979). *Arista e Designer*. Lisboa: Editorial Presença/Martins Fontes.

_________ (1995). *Design e Comunicação Visual*. Lisboa: Edições 70.

NARDI, Bonnie A. (1992). «The use of scenarios in design». *SIGCHI Bull* 24 (3): 13–14.

PINK, Daniel. H. (2006). *A Whole New Mind: Why Right-Brainers Will Rule the Future*. Penguin.

REBELO, Francisco. et al. (2011). «Virtual Reality in Consumer Product Design: Methods and Applications». In *Human Factors and Ergonomics in Consumer Product Design: Methods and Techniques*, editado por Waldemar Karwowski, Marcelo M. Soares, e Neville A. Stanton, 381–402. CRC Press.

SCHANK, Roger. (2011). *Teaching Minds: How Cognitive Science Can Save Our Schools*. Teachers College Press.

SIK LÁNYI, Cecília, ed. (2012). *Applications of Virtual Reality*. InTech.

SIK LÁNYI, Cecília, LÁNYI, Zsuzsanna and TILINGER, Ádám. (2003). «Using Virtual Reality to Improve Space and Depth Perception». *Journal of Information Technology Education* 2: 291–303.

SORBY, Sheryl A. (1999). «Developing 3-D Spatial Visualization Skills». *Engineering Design Graphics Journal* 63 (2): 21-33. http://diggingdeeper.pbworks.com/f/Developing+Spatial+Skills.pdf.

STEADMAN, Philip. (2008). *The Evolution of Designs: Biological Analogy in Architecture and the Applied Arts*. USA and Canada: Routledge.

WONG, Wucius. (1995). *Fundamentos del diseño*. 4ª ed. Espanha, Barcelona: Gustavo Gili.