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ANA GLÓRIA BARÃO
DOS SANTOS NEVES

BASIC DESIGN INNOVATION WITH THE CONTRIBUTION OF VIRTUAL REALITY-BASED TOOLS

Tese apresentada ao IADE - Faculdade de Design, Tecnologia e Comunicação da Universidade Europeia, para cumprimento dos requisitos necessários à obtenção do grau de Doutor em Design, realizada sob a orientação científica da Doutora Maria Emília Capucho Duarte, Professora Catedrática da Universidade Europeia e da Doutora Diana da Silva Dias, Professora Catedrática da Universidade Lusófona.

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Faculdade de Design,
Tecnologia e Comunicação
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palavras-chave Design; Educação em Design; Design Básico; Objetivos de Aprendizagem; Realidade Virtual Imersiva.

resumo

O futuro da educação em design tem sido amplamente discutido, reforçando algumas das considerações encetadas na transição do milénio sobre como preparar os jovens para serem designers numa cultura de sistemas complexos. Tais considerações enfatizam a tecnologia digital e como esta impactará os tempos que virão, em grande parte devido à integração da *cyber* tecnologia nas esferas individuais e coletivas. Não podíamos prever, entretanto, a rapidez com que a mudança seria imposta. As medidas de proteção contra a pandemia de Covid-19 forçaram novas prioridades, diminuíram os recursos e condicionaram as interações presenciais, aumentando assim a preponderância da tecnologia digital que veio testar a capacidade de reformular e reinventar a vida na maioria das áreas da sociedade. Surge então o problema de como a tecnologia digital impactará o ensino em design, e particularmente, o ensino-aprendizagem do Design Básico, em toda a sua dimensão holística.

A educação, em geral, e a educação em design, em particular, são áreas de intervenção prementes, exigindo contextos de aprendizagem a distância e melhores soluções tecnológicas digitais. Isto acresce ao principal objetivo da educação, que é proporcionar um momento de despertar para uma vida digna. Buchanan aponta a educação como uma "preparação intelectual para a aprendizagem ao longo da vida que cultiva as capacidades da mente para encontrar novas situações e responder com engenhosidade, imaginação e criatividade" que transcende a especialização. Essas foram as características mais procuradas durante o *vorkurs*, posteriormente designado Design Básico (DB), que na Bauhaus School of Design acabou por estabelecer o domínio da aprendizagem do design ao longo da vida, para o futuro. Nas suas premissas originais, o DB aspirava a "formar cada jovem de maneira que se desenvolvesse de modo original, características de si mesmo para continuar a ser um criador" de acordo com Wick, como meio para alcançar o equilíbrio necessário entre "investigação científica e tecnologia voltada para o exterior... [e] ... pensamento voltado para dentro, e pelas forças espirituais" como referiu Johannes Itten. Moholy-Nagy reforçou o *foundational course* como um método "para manter, no trabalho do adulto, a sinceridade da

emoção, a verdade da observação, a fantasia e a criatividade da criança."

A mudança sistémica trazida pela era pós-moderna, em meados do século 20, afetou a prática e a educação em design, que tiveram de enfrentar as rápidas mudanças na ciência e tecnologia e o seu impacto social e ambiental. Num âmbito ampliado de intervenção do design na sociedade com desafios crescentes, o pensamento sistémico deve ser adotado pelos designers, permitindo-lhes atuar como "integradores e generalistas que podem ajudar a colocar a contribuição de cada disciplina em relações sistémicas e ajudam a contextualizar as contribuições dos especialistas" como refere Daniel C. Wahl. O designer é, de facto, parte do sistema, devendo ser feito um investimento na educação em design no sentido de estruturar mais uma forma de ser humano, através do design (isto é, proporcionado pelo design da aprendizagem) e no design (ou seja, na área de design). Para que o Ensino Superior se centre em proporcionar experiências de aprendizagem com essa intenção, é essencial considerar a abordagem holística de ensino-aprendizagem que caracterizou a origem da educação em design e, particularmente, o Design Básico. Esta disciplina corresponde ao ensino-aprendizagem dos fundamentos do design, é frequentemente lecionada nos momentos iniciais dos cursos de design, sendo considerada um dos principais componentes da educação em design.

Na educação em design, a tecnologia digital é cada vez mais reconhecida como um componente indissociável de qualquer abordagem pedagógica, para a qual devem ser considerados os seus efeitos para a espectável transformação de modelos e processos educativos. Neste contexto, a Realidade Virtual (RV) será inevitavelmente introduzida. RV é um meio tecnológico digital que envolve interação intuitiva e em tempo real, em mundos 3D sintéticos, onde as experiências artificiais tendem a igualar-se às reais, dependendo da capacidade imersiva do sistema de RV. Espera-se que tecnologias imersivas, como a RV imersiva (RVi), se tornem mais importantes e proeminentes, segundo tom Dieck, Jung e Loureiro, abrindo ainda mais possibilidades de aplicação da RV enquanto amplia o seu potencial de influenciar e redefinir a cultura.

Na última década, cresceu o interesse por explorar o impacto de ferramentas baseadas em RV no contexto do DB, onde a RV se mostra vir a ser um aliado promissor. O nosso estudo vem contribuir para este tema ao abordar a potencialidade das ferramentas baseadas em RVi para proporcionar à pedagogia do DB o seu caráter holístico e, consequentemente, fornecer experiências de ensino-aprendizagem envolventes e eficazes. Para abordar o assunto adotámos uma abordagem metodológica de métodos mistos, ou seja, que envolveu métodos qualitativos e quantitativos.

O primeiro estudo pretendeu responder à questão acerca da potencialidade prática da associação entre o DB e a RV, pelo que implementámos um estudo quase-experimental no contexto de uma unidade curricular derivada do DB, que proporcionou aos alunos a oportunidade de interagir com estruturas 3D num ambiente virtual semi-imersivo. O objetivo consistiu em avaliar o impacto da experiência com RV na perceção da criatividade; na perceção das barreiras à criatividade; na perceção da motivação; no desempenho; e no estado emocional durante a experiência.

No estudo seguinte focámos as questões de como reconhecer o DB no Ensino Superior e quais os objetivos de aprendizagem mais representativos deste ensino-aprendizagem, tendo em vista a criação de uma ferramenta baseada na RV. Deste modo, prosseguimos com a identificação: i) das possíveis unidades curriculares que lecionam o DB; ii) dos objetivos de aprendizagem (OA) utilizados nessas unidades curriculares, definidos pelas suas componentes: níveis de compreensão e conteúdos; iii) e das combinações mais significativas entre os componentes dos OA.

Constatada a falta de uma orientação prática para a criação de atividades e ferramentas de aprendizagem de DB que respeitem a sua origem holística, deparámo-nos com a questão de como enquadrar esta filosofia no sistema de Ensino Superior atual e como pode ser implementada no contexto das atividades de uma unidade curricular que vise o ensino-aprendizagem dos fundamentos do design. Nesse sentido, desenvolvemos um quadro conceptual/modelo que conecta as premissas teórico-filosóficas do DB e os OA e que visa: i) a montante, orientar os professores na análise, transformação, e criação de novas atividades de aprendizagem holísticas; ii) e a jusante, envolver os estudantes em experiências de aprendizagem que os preparem para resolver problemas sociotécnicos complexos, em design. A proposta resultante aplica-se ao design de todas as atividades de aprendizagem de DB, não restringindo aquelas que utilizem as tecnologias digitais.

Finalmente, de modo a perceber qual a potencialidade da aplicação do quadro conceptual/ modelo na criação de ferramentas de iRV, desenvolvemos um questionário online, de acordo com uma abordagem do Design Centrado no Humano (DCH) que avaliou, junto de antigos estudantes de DB: i) a relevância e a qualidade das anteriores experiências de aprendizagem dos fundamentos do design; ii) a familiaridade com a tecnologia RV e as expectativas quanto ao uso da RVi para diversas fases do processo de ensino-aprendizagem, incluindo para desempenhar os OA. Foi demonstrado que os estudantes revelam motivação para utilizem ferramentas baseadas na RVi e expectativa de que estas contribuam para desempenhar os OA mais significativos, em todos os níveis compreensão e conteúdos programáticos. Os resultados apontam ainda para o facto das ferramentas de RVi poderem vir a contribuir para superar as dificuldades de aprendizagem relativamente a fundamentos do design percecionados como mais desafiantes, como Princípios da Forma 3D.

Esta investigação aponta para a pertinência da utilização da tecnologia RVi para a aprendizagem dos fundamentos do design, no contexto de uma pedagogia holística, que promove a coerência entre o corpo, mente e espírito, como na sua versão original, e envolvendo os estudantes numa aprendizagem cativante e eficaz, que os prepare para enfrentar os desafios pessoais, em concomitância com a abordagem dos problemas complexos sociotécnicos, em design.

A nossa proposta não se restringe a nenhum método de ensino-aprendizagem, podendo adequar-se às necessidades de aprendizagem específicas dos estudantes e a qualquer metodologia de ensino, em qualquer área de design. Destina-se à condução holística dos seres humanos, no sentido de uma antropagogia, dirigida a todos, independentemente da idade e do nível de ensino, através do design e em design.

keywords Design; Design Education; Basic Design; Learning Outcomes; Immersive Virtual Reality

abstract The Higher Education (HE) system faces the challenges of providing a holistic education to the future designers, enabling them the capacity to approach the increasingly complex socio-technic problems. The challenge seems aggravated by the accelerated digitalization of education. However, digital technological mediums, such as Virtual Reality (VR), offers unique effective contributions to many educational settings. VR enables real-time and intuitive interactions, in synthetic 3D worlds, where artificial experiences tend to produce the same effect as the real ones, depending on the immersive capacity of the VR system. Immersive VR (iVR) is expected to become more important and prominent, opening more possibilities for VR to expand its potential to influence and redefine culture. The problem then arises of how digital technology will impact the teaching in design, and particularly, the teaching-learning of Basic Design, in all its holistic dimension. The problem then arises of how digital technology will impact the teaching in design, and particularly, the teaching-learning of Basic Design, in all its holistic dimension. In this sense, our study focuses the questions: In the context of the development of Basic Design (BD) skills (i.e., the teaching-learning of the design fundamentals), can, and how can iVR-based tools contribute to refill HE system its holistic nature and capacitate designers to address the world's complex socio-technical problems? To approach the question, a set of studies were implemented following mixed methods research. The first question to be addressed concerned the capacity to create, implement and test the impact of a VR-based tool on the BD context. Accordingly, a rudimentary VR-based tool was developed and tested, in the pedagogic context of a BD-derived curricular unit. Its impact was assessed on the students' creativity level; barriers to creativity; motivation; performance; and emotional state during the experience. The following study aimed the identification of the learning outcomes (LOs) that future VR-based tools should address, for which a new study was conducted to recognize BD in the Portuguese HE system, as well as its most representative learning outcomes (LOs). Were identified: i) the curricular units that teach DB; ii) the LOs, defined by their components: levels of understanding

and content topics; iii) and the most significant combinations between those components. Subsequently, was addressed the question: How can BD reflect its holistic nature in the present HE system? A conceptual framework-model that connects the theoretical-philosophical premises of BD and the LOs was proposed. The conceptual framework-model may enable the design of holistic BD learning activities, tools and experiences in general, including the ones that use digital technology. The final question concerned the expectations of the BD students to use iVR-based tools for learning the design fundamentals holistically. An online questionnaire identified that the expectations of previous BD students to use the iVR-based tools for several phases of the teaching-learning process is high, as well as for performing the LOs, particularly for surpassing the learning of the most difficult content topic, 3D form creation. It is therefore proposed that the conceptual framework-model can be used for assisting the design of innovative pedagogical tools based on VR, that supports BD holistic premises, thus contributing to a more consistent integration of iVR-based tools in BD pedagogy. Hopefully, this can lead to the acquisition of more and better skills among design students while reaffirming the holistic character of the BD teaching-learning process, particularly when assisted by iVR-based tools.

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Glossary acronyms and abbreviations

- HE - Higher Education: HE, is considered the basis of the professional training of designers, granting them certification for the profession.

- BD - Basic Design: BD is the teaching and learning of the design fundamentals. Overall, basic design provides a solid foundation for aspiring designers, helping them develop a common language, critical thinking skills, and a deep understanding of the visual principles that underlie effective design work.

- VEs - Virtual Environments: VEs are immersive computer-generated spaces designed to simulate real or fantastic environments. VEs are a fundamental component of virtual reality experiences, creating a sense of presence and immersion for users. These environments can have a varied level of detail and interactivity, allowing users to interact with objects, explore the environment and sometimes even alter the virtual world.

- VR - Virtual Reality: Virtual Reality (VR) is a computer-generated simulation of a three-dimensional environment, often experienced through immersive headsets or display systems, that enables users to interact with and explore synthetic worlds or scenarios. VR technology leverages advanced graphics, audio, and often haptic feedback to create a sense of presence, transporting users into a digitally constructed environment that can simulate real-world experiences, abstract spaces, or fictional realms. This technology facilitates user engagement, interaction, and sensory experiences within the simulated environment, making it a versatile tool for applications ranging from entertainment and education to training, research, and therapeutic interventions.

- iVR - Immersive Virtual Reality: iVR refers to an advanced form of virtual reality technology that creates an all-encompassing, highly realistic digital environment that completely surrounds, and engulfs users, providing them with a deep sense of presence and immersion. iVR typically involves the use of specialized headsets or display systems that cover the user's field of view and can track their head movements to update the displayed environment accordingly. The concept of iVR represents a significant advancement in virtual reality technology, offering a level of immersion that can deeply impact users' experiences and behaviors within the virtual environment. As technology continues to evolve, iVR systems become more sophisticated, enabling increasingly convincing and engaging simulations.

- LOs - Learning Outcomes: LOs are descriptions of abilities expected from learners as result of learning experiences. They are also identified as: academic goals; expected results; and learning objectives.

- AUs - Activity Units: AUs are the expected performance of the students during the learning activities, to enable the LOs in the end of a learning cycle.

Chapter I

> If you want to teach people a new way of thinking, don´t bother trying to teach them. Instead, give them a tool, the use of which will lead to new ways of thinking.
>
> Buckminster Fuller

1. Introduction

1.1. Problem definition

The future of design education has been widely discussed, thereby reinforcing considerations taken since the millennium transition (e.g., Buchanan, 2001; Findeli, 2001). Largely due to the accelerating technological transformation and exacerbating environmental problems, the debates reflect the concerns about preparing young people to be designers in a complex systems culture (e.g., Frascara, 2020; Meyer & Norman, 2020; Norman, 2016; Redström, 2020). Special consideration is given to how digital technology will impact the times to come, largely due to the integration of cyber-tech in individual and collective spheres. We could not predict however how quick the change would be imposed. Covid-19 pandemic protective measures forced new priorities, diminished the resources, and conditioned presential interactions, thus increasing the preponderance of digital technology while testing our capacity to reframe and reinvent our lives in most areas of society.

Education in general and design education in particular are pressing areas of intervention, demanding for remote learning contexts and better digital technological solutions. This adds to the main general goal of education, which is to provide an awakening moment and enabling a worth living life (Frascara, 2020, p. 116). Buchanan points it as an “intellectual preparation for life-long learning that cultivates the capabilities of the mind to encounter new situations and respond with ingenuity, imagination, and creativity” (Frascara, 2020, p. 109) that transcends specialization.

These characteristics were mostly sought at the Bauhaus vorkurs that ended up establishing the domain of lifetime design learning for the future (Lerner, 2005, p. 223). In its original premises, Basic Design (BD) aspired to “form each young man in such a way that he develops in an original way, characteristic of himself so that he continues to be a creator,” (Wick, 1993, p. 101) as a means to achieve the required balance between “outward looking scientific research and technology…[and]…inward looking thinking and by spiritual forces” (Itten, 1975, p. 9). Moholy-Nagy reinforced the foundation course as a method “to keep, in the work of the grown-up, the sincerity of emotion, the truth of observation, the fantasy, and the creativeness of the child” (Moholy-Nagy, 1947a, p. 21).

The systemic turn brought by the postmodern era, in the middle of the 20th century, affected design practice and design education that had to confront the rapid change undergoing in science and technology and its impact on the larger social and environmental scales. Towards an amplified scope of design intervention in society and increased wicked challenges, designers must engage in systemic thought (Nelson, n.d.; Nelson & Stolterman, 2012) enabling them to act as “integrators and generalists who can help to put the contribution of each discipline into systemic relationships and help to contextualize the contributions made by the specialists” (Wahl, 2016, p. 63).

The designer is, in fact, part of the system being considered (Findeli, 2001, p. 10), for which an investment should be made in design education towards structuring more a way of being human, through design (i.e., afforded by learning design) and in design (i.e., within the design area). For the Higher Education (HE) system to focus on delivering learning experiences with this intention is essential to consider the holistic approach to teaching and learning that characterized the origin of design education, and particularly, BD. It corresponds to the teaching-learning of the design fundamentals, frequently at the introductory course of the design undergraduate curricula. BD is still considered one of the main components in design education (e.g., Boucharenc, 2006b; Cross, 1983; Findeli, 2001).

In design education, digital technology has been acknowledged as an inseparable component of any pedagogical approach, for which its effects for the expected transformation of educational models and processes must be considered (Colucci, 2011). In this context, Virtual Reality will be inevitably introduced as this allows access to artificial reality through the production of new objects and environments, which can resemble reality in great detail (Colucci, 2011). This technology has shown positive impact on an increasing number of educational areas, including design education (e.g., Angelino, 2020; Bossard et al., 2008; Lee, 2011). VR involves interacting intuitively and in real time, in 3D synthetic worlds, where the artificial experiences tend to equal the real ones, more as much the immersive capacity of the VR system. Immersive technologies, as immersive virtual reality (iVR), are expected to become more important and prominent (tom Dieck et al., 2021). According to Myron Krueger, virtual reality "is the first intellectual technology that permits the active use of the body in the search for knowledge" (Heim, 1994, p. viii), with possibility of being applied to every human activity and to mediate in every human transaction, with a wide potential to impact and redefine the culture (Heim, 1994). With the inevitability of iVR being used in design education, during the last decade the interest has grown towards exploring the impact of VR-based tools in the BD context, where it shows to be a promising ally (e.g., Liu, 2020; Neves et al., 2017; Obeid, 2019; Özgen et al., 2019).

To summarise. The digitalisation of education is taking place at an accelerated pace, covering all areas of knowledge, including design. The introduction of technological tools such as Virtual Reality is being pointed out as a growing trend, as it will allow remote, distance learning, to benefit from some typical studio-like pedagogical practices, such as action-reflection. Although there are studies on the application of virtual reality in teaching (Kavanagh et al., 2017; Abdelaziz et al., 2014; Bossard et al., 2008), not much is known about the efficiency of using VR in teaching the fundamentals of design (Basic Design) and how to design both the curriculum and the tools in a way that enhance the teaching-learning of design fundamentals.

In this context, our global research problem is to understand the potential of iVR for teaching DB and what impact it will have on the training of future designers, considering as a basic premise that this subject should stimulate the systemic thinking needed to deal with complex problems, acting in an increasingly digital ecosystem where part of the academic processes will take place remotely. This global problem can be explored in its two sub-parts, in particular regarding assessing the effectiveness of VR for Basic Design Education; and designing a BD iVR compatible curriculum.

Proposition: Virtual Reality-based tools contribute for a holistic approach to the teaching-learning of the design fundamentals, in an increasingly digitalized Higher Education system.

1.2. Research questions

Considering the problems identified above, the research questions we have defined are as follows:

Main question:

- Can VR-based tools support BD pedagogy's holistic character, while providing engaging and effective teaching-learning experiences in an increasingly digital education system?

Secondary questions:

- What are the main characteristics of Basic Design discipline and how it evolved?
- How does learning design fundamentals in an iVR environment compare to traditional methods in terms of student comprehension, engagement, and skill retention?
- What are the Learning Outcomes that should be addressed in Basic Design?
- Can and how can the original holistic premises of Basic Design assist the present and future of design education?
- How can a Virtual Reality-based tool be in fact, created, implemented, and tested in the Basic Design context?
- What are the expectations of the students towards the use of immersive Virtual Reality in the teaching-learning process, including to perform the Learning Outcomes?

1.3. Objectives

Similarly, following on the problems and research questions listed above, the objectives we have set are as follows:

Main objective:

The main objective of this research is to understand if, and how, VR-based tools can afford BD pedagogy's holistic character and, consequently, to provide engaging and effective teaching-learning experiences.

Secondary objectives:

To approach the subject, other specific objectives were defined.

Firstly, we wanted to explore the VR technology we had at our disposal and how students perceived it. The findings of this phase would be a starting point for the following stages. So, in a first stage, we focused our efforts on building a rudimentary version of an immersive VR system that would allow the digitisation of a classic BD exercise. To do this, we used one of the exercises used in a design degree course at IADE.

Simply digitising the existing exercises would not achieve the general objective, so it was necessary to understand how the DB was being used in other schools. In particular, we were interested in understanding what the main LOs of the BD discipline would be, in order to use this information to design the structure of a future tool. This knowledge would be fundamental to building a tool versatile enough for adoption in multiple contexts and multiple approaches. As such, the next objectives were identifying the:

i) Portuguese curricular units in Design courses that lecture BD;

ii) LOs used in those curricular units, defined by its components: levels of knowledge and content topics;

iii) Most relevant combinations of LOs components, defined by frequency and importance in Portuguese BD courses.

The next objective was to design a conceptual framework-model that connects the theoretical-philosophical premises of BD and the LOs to:

- upstream, guiding teachers and design learners in analysing and criticizing current learning activities, identifying the need for systematic adaptations and adjustments to support more or less profound transformations in setting of new learning activities;
- and downstream, to engage the freshmen in learning experiences that awaken them to a meaningful life-learning journey, in-through design.

Finally, an online questionnaire was created to assess the quality of previous BD learning experiences and the expectations regarding the use of iVR at the various phases of the teaching-learning process, including the LOs that would benefit the most from these tools.

Table 1 shows the link between problems, research questions and objectives.

Table 1: Link between problems, research questions and objectives.

Main Problem:	Main Research question?	Main Objective
What is the potential of iVR for teaching BD in an increasingly digital and remote educational context, where systemic thinking is critical?	Can VR-based tools support BD pedagogy's holistic character, while providing engaging and effective teaching-learning experiences in an increasingly digital education system?	Understand if, and how, VR-based tools can afford BD pedagogy's holistic character and, consequently, to provide engaging and effective teaching-learning experiences
Secondary Problems:	**Secondary Research questions:**	**Secondary Objectives:**
What is the effectiveness of iVR for learning the Design Fundamental	What are the main characteristics of BD discipline and how it evolved?	Identify the main characteristics of BD discipline and explain how it evolved.
	How can a Virtual Reality-based tool be in fact, created, implemented, and tested in the BD context?	Build a rudimentary version of an immersive VR system for students exploration.
	How does learning design fundamentals in an iVR environment compare to traditional methods in terms of student comprehension, engagement, and skill retention?	Evaluate the impact of the students interaction with the VR pedagogic tool.
How to design a BD iVR adequate curriculum?	What are the LOs that should be addressed in BD?	Identify the LOs that are usually addressed in BD.
	Can and how can the original holistic premises of BD assist the present and future of design education?	Design a conceptual framework-model that connects the theoretical-philosophical premises of BD and the LOs.
	What are the expectations of the students towards the use of iVR in the teaching-learning process, including to perform the LOs?	Assess the students' expectations towards the use of iVR in the teaching-learning process, including to perform the LOs.

1.4. Motivation

There are several arguments that can be put forward to explain the need and relevance of this study:

- *Contributions to Academia:* Many changes have taken place in design education. The implementation of the Bologna Declaration (1999) at the turn of the millennium has been one of the most impactful in recent times. This fact has been influencing design education all over Europe, including the ways the freshmen are being introduced to the design fundamentals, in BD pedagogy. It is expected the increasing of online Design courses and remote online teaching-learning, due to emergency situations or distance learning.
- *Emerging trends and technologies:* New digital technologic mediums appear to be promising and valid alternatives and/or complementary solutions to assist the learning process, particularly due to the appealing and high engaging experiences they can provide. This aspect makes of VR digital technologic medium with a high

potential for assisting design education and BD purposes characterized by its holistic pedagogical approach.

- *Theoretical Significance:* This study contributes to the theoretical framework of the field of Design, as our findings can refine existing theories about the use of BD. Traditional theory-philosophy from the main pedagogues, Johannes Itten, Moholy-Nagy, Attílio Marcolli and others, are reflected in terms of the structure of HE based on Learning Outcomes, for which a framework-model was developed.
- *Practical Relevance:* The results of this study could be useful for all those around the world who wish: to create VR tools for teaching BD, and eventually, study its impact on pedagogic aspects; to acknowledge the BD in the Portuguese HE system, including the LOs present it the BD study plans; apply a framework-model to design a more holistic BD pedagogy.
- *Social importance:* Any designer with the capacity to see the problems from a broader perspective that includes many points of view, according to a systemic approach, is more likely to contribute effectively to address and solve the growing complexity of the problems in both social and technical dimensions.
- *Personal Interest:* Sometimes researchers are motivated by personal experiences, interests, or passions related to the research topic. This research also shares this reality. Having been teaching Basic Design on the design degree programme at IADE since 1999, the author (PhD candidate) felt motivated to contribute to her chosen field. The intention was not to carry out an auto-ethnographic investigation (Atkinson & Delamont, 2011), but to use an approach compatible with the socio-critical vision (Feenberg, 1991) although inevitably both approaches end up being present in some way.

1.5. Methodological approach

The Socio-Critical Approach, rooted in the Frankfurt School's Critical Theory (Raymond, G., 1981), can be considered the overarching philosophical framework for this study. Critical pedagogy, human emancipation, interdisciplinary inquiry and social transformations are the key characteristics and concepts that motivated us to adopt this approach, because rather than creating a tool and giving guidelines for future developments, our motivation was also to critically examine the impact on the socio-technical framework of introducing VR in the BD teaching-learning process while promoting a socially orientated Design vision. In this context, the methodological approach used in this study consisted of a mixed methods research, as it required both quantitative and qualitative methods in the different phases (Creswell & Clark, 2017), although more of the latter were adopted.

This research was organised into four major studies. The flow of the research, its stages and relationships with the research questions, as well as the location in this document are illustrated in Figure 1.

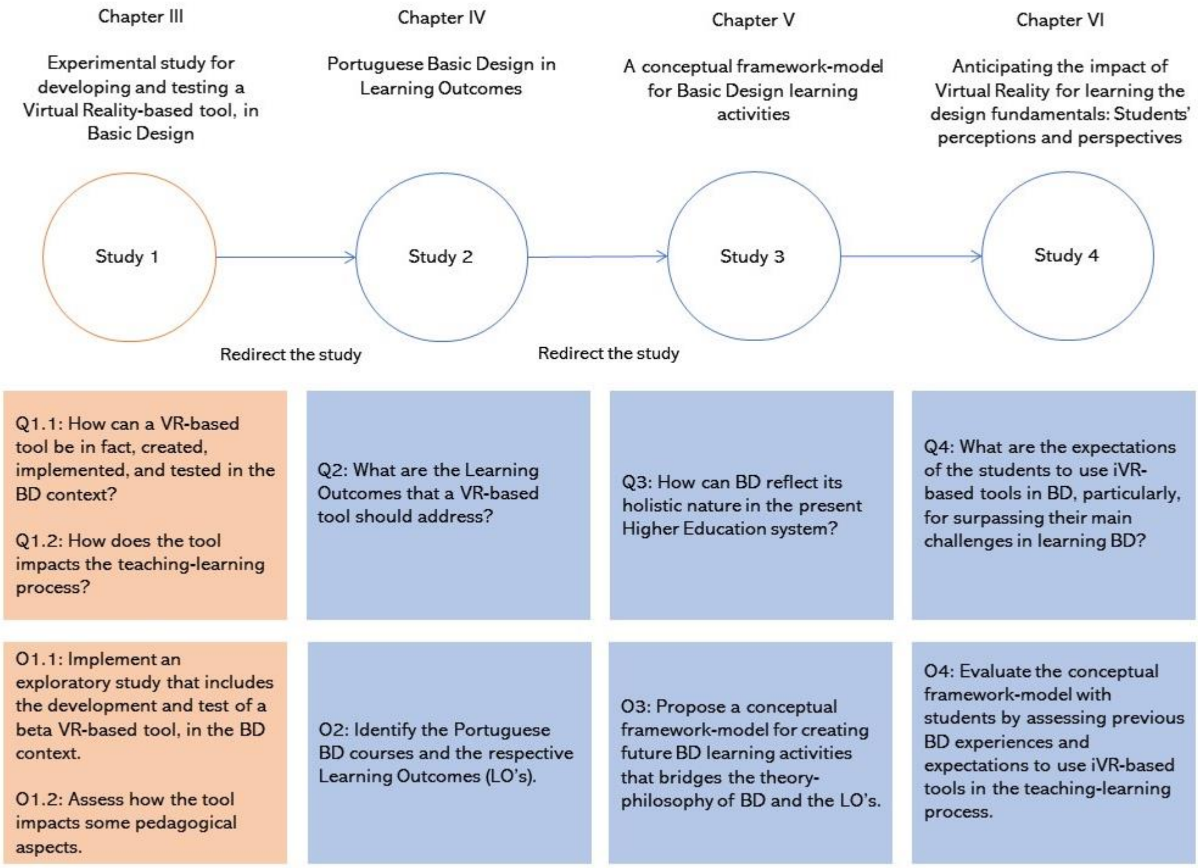

Figure 1. Outline of the research.

The first phase of the research started with a literature review that enabled the identification of the main concepts, namely BD and VR, and the possible alliances between them to assist the teaching-learning process, with a particular focus on the *Laboratório de Design 3D* course, from the graduation in Design at IADE.

Next, a quasi-exploratory study was implemented for exploring the potentialities of the available technology while affording students the opportunity to interact with 3D structures in a VR system. A mixed design was used with two groups of students (control group vs.

experimental group). The first used the non-digital conventional methodology (verbal and 2D images) and the latter used a hybrid methodology (VR plus verbal and 2D). The dependent variables under assessment were: Perception of barriers to personal creativity, Creativity level, Self-perception of creativity and motivation inventory; Performance and Perceived emotional state of the students during the experience (made by video analysis) using Product Emotion Measurement Instrument (PrEmo) (Desmet, 2003). This step allowed the assessment of the impact on some aspects of the teaching-learning process as well as the students' emotional responses to the experience.

The next phase of the research consisted of contextualizing BD within the Portuguese design education scenario. The BD in the present design courses was characterizing in three phases: i) mapping possible existent Portuguese BD curricular units; ii) identification of the LOs present in the curricular units, in its main components (i.e., levels of knowledge and content topics) as defined in the constructive alignment theory; iii) and identification of the prominent combinations of levels of knowledge and content topics used in the Portuguese BD courses. For identifying the Portuguese BD curricular units, we mapped BD in the present scenario of HE by using a conceptual matrix created for this purpose. The matrix required a systematic analysis of the main literature related to BD, specifically the documents produced by the design teaching pioneers that largely influenced the origin of Portuguese design education. The study plans previously collected were analysed according to the conceptualized matrix, which allowed the identification of the BD-derived Curricular Units. For setting the two other objectives of identifying the LOs present in the curricular units, in its main components (i.e., levels of knowledge and content topics) and the prominent combinations, a qualitative approach was applied, using MaxQDA software for the content analysis.

The following study was about developing a conceptual framework-model that resulted from a reflection largely based on the experience as a BD teacher for adapting the theoretical-philosophical premises of BD to the LOs, by which learning activities can be more aligned with a holistic BD pedagogy.

The last study was concerned with the assessing of students' expectations about the future use of iVR-based tools for learning the design fundamentals, for which was used a Human-Centred Design (HCD) approach. We created an online questionnaire and disseminated it internationally by email, with teachers, that passed them to the students. The collected data was analysed using IBM SPSS statistics for Windows, v. 27 (IBM Corp., 2020). A descriptive statistics was applied according to Marôco (2021).

1.6. Constraints to the study

This research went through some challenges that affected the study itself, but despite the deviations the overall objective was always maintained.

The exploratory study was initially planned as an experimental study, part of a larger project that intended the design of a VR-based tool to be applied in the teaching activities of a BD-derived curricular unit of the IADE graduation in design course. A beta version of the VR tool was developed, and a few trials were run with students during a semester, however, despite the positive overall reactions from the students, the somehow inconclusive results, and the lack of permission from the professor coordinating the target curricular unit to proceed with the experimental study in the classroom, forced us to redefine the study.

Therefore, in the revised study, the creation of a VR-based tool for learning a set of BD skills gave place to the definition of the most important LOs of BD. The impact of the tool in the students' performance of the LOs would be assessed through an experimental controlled simulation of a class. However, the emergence of the pandemic of COVID-19 and the strict safety measures that followed closed the research facilities and made impossible to proceed with the research as planned.

Once more, we were forced to implement a new redefinition of the research plan, this time with a more theoretical-based approach. The development of the tool was replaced by the development of a conceptual VR-based tool created to assist the design of BD learning activities. Its validation within the classroom gave way to an evaluation of perceptions by means of an online questionnaire.

1.7. Structure of the document

This document is structured in 7 Chapters. We firstly introduce and define the research topic in Chapter I before addressing the theoretical framework-model, in Chapter II and the state of the art surrounding the main concepts, Basic Design and Virtual Reality. The following chapters describe the sequential studies conducted for achieving the research objectives.

Therefore, Chapter III addresses the implementation of an exploratory study in which we developed and tested a beta VR-based tool in an educational context. In Chapter IV the LOs present in the Portuguese BD courses are identified. Chapter V is dedicated to the proposal of a new conceptual framework-model for creating future BD learning activities that bridges the theory-philosophy of BD and the LO´s. Finally, Chapter VI reveals the expectations of previous BD students to use iVR-based tools in the teaching-learning process, while evaluating the conceptual framework-model. The document closes with the concluding Chapter VII.

Chapter II

In the present state of the world, the control we have of physical energies, heat, light, electricity, etc., without control over the use of ourselves is a perilous affair. Without control of ourselves, our use of other things is blind.

John Dewey

2. Theoretical Framework

2.1. Abstract

The research in basic design (BD) education has been growing, thus pointing to its importance and actuality, around the world. Partly due to the increased use of digital technology on design education, BD has been reorienting its teaching-learning practices to include digital technology, as the new generations of students are ever more familiarized with the different digital technology. VR digital medium has been progressively introduced in design education, particularly in BD. Therefore, we performed a literature review concerning the main matters: Basic Design and Virtual Reality, complemented with a reflection about the potentiality and interest of Virtual Reality (VR) for innovation in the Basic Design education.

2.2. Introduction

In education, the interest in researching the connection between BD and VR has been increasing worldwide due its potentiality (e.g., Kavanagh et al., 2017; Radianti et al., 2020a). Concurrently, the XXI century designers are increasingly sooner familiarized with the new digital technologies, printing a changing point into current teaching methodologies. The irreversibility and intensification of these phenomenon have driven the practice and evaluation of new learning environments and teaching methods. Therefore, design education faces new challenges and opportunities, delivering new pedagogical approaches (Gu et al., 2010). Despite the recent advances, BD remains unexplored regarding the use and impact of new technologies in the teaching-learning process, specifically VR, setting a venue for research. This exploratory study presents possible impact of that partnership. Contextualized in the design area, our study will depart from a clarification of the term design and continue around the two main matters: BD and VR.

2.3. Design

Design is currently defined in an increasingly wider territory (e.g., Bonsiepe, 2019; Buchanan, 2001; Meyer & Norman, 2020) with unfathomable challenges and possibilities for the future of the planet. The proliferation of the concept manifests in the many areas of intervention (e.g. poster design, exhibition design, packaging design, type design, textile design, industrial design, corporate identity, service design, game design and web-design, discourses design, interaction design, experience design, policies design, systems design, regenerative cultures design, eco design, environmental design, etc). The concept also manifests in different design approaches (e.g., experience design, transformational design, critical design, radical design, inclusive design, post-utopian design, speculative design, calm design, participatory design, human centred design, user-centred design, co-design, etc.).

Design is the process of realizing an intention, in the mind, first, and then manifesting it in the exterior. The core of design as a natural and ancient human capacity that permeates most aspects of life, as reflected in "our cosmologies, our homes, our businesses, and our lives, as well as our material artifacts [means] the ability to imagine that-which-does-not-yet-exist, to make it appear in concrete form as a new, purposeful addition to the real world." (Nelson & Stolterman, 2012, p. 12). The authors consider design "the first tradition among many traditions of human inquiry and action developed over time, including art, religion, science, and technology" (Nelson & Stolterman, 2012, p.1) with a particular culture of its own. In fact, design can be considered a second nature, and similar to the primordial nature, is responsible for the creation of highly valued things in life (Fuller, 2002; Nelson & Stolterman, 2012). However, one major difference was pointed by Buckminster Fuller. The primordial nature didn't require from any of its perfect interdependent components the artificial requirements invented by men by which they guide their existence: "I noted that nature did not require hydrogen to "earn a living" before allowing hydrogen to behave in the unique manner in which it does. Nature does not require that any of its intercomplementing members "earn a living".

(Fuller, 2002, p. 144). Fuller undertook his design profession in a unique way, which he named "The Critical Path". Using self-discipline and an unusual capacity to detach from the personal conditioning, he affirmed to be serving all humanity and nature itself. One of his rules, besides unpersonal self-observations that he registered methodically, was his commitment to not follow the need to earn a living according to humanity´s established economic system, but to a devoted alignment with the principles of nature itself:

> Since nature was clearly intent on making humans successful in support of the integrity of eternally regenerative Universe, it seemed clear that if I undertook ever more humanly favorable physical-environment-producing artifact developments that in fact did improve the chances of all humanity's successful development, it was quite possible that nature would support my efforts, provided I were choosing the successively most efficient technical means of so doing. (Fuller, 2002, p. 144)

Buckminster Fuller's design path depicted in the first person, reveals his committed efforts towards a self-development that required more of a technology of the self, or a "design of the self" that lead to a life dedicated to improving human's conditions in the world and the world itself. This resonates with Findeli's proposal for providing a design education conductive of an intuitive thought, what can be done through an aesthetic education (Findeli, 1994), enabling to perceive the invisible relations between the elements of a system, in all its complexity. Findeli calls the attention for the potential of BD to developing some essential competences in the designer, through the practice of "spiritual exercises" (Findeli, 2001, p. 16), allowing leadership capacity, and the access to a zone of unpersonal self-observation from which the interests of the ego are replaced by a wider, disinterested and holistic perspective of the world phenomena (Findeli, 2018). To achieve it, Findeli proposes engaging in a metamorphosis of the designer, a design of the self that freshmen may start developing in, as in the BD original premises. In a similar way, design education should start (re)focusing nowadays on the development of a technology of the self, by which future designers may build solid inner competences for designing the world.

2.3.1 Design definition

Although many existing design definitions highlight different perspectives of a complex and very difficult subject, we find adequate for the purpose of our study to focus on two aspects. The first relates to Flusser's perspective of the designer. According to the philosopher, from the two ways of seeing the phenomena, seeing time and seeing eternity, the latter was considered the way of seeing of the prophets, now called the designers. A designer sees in the direction of eternity and is able to reproduce what has been seen (Flusser, 2018). As a teleological activity, design requires the synoptic effect in which the perception of different states of a machine, past, present and future are manifested simultaneously (Maturana & Varela, 2004). To devise it, a set of procedures are required for bringing to concrete reality something sought with the eyes of eternity, in a pre-existent "virtual" reality. Those relate "non-discursive intelligence, including aesthetic or sensorial competence understood as the capacity to make perceptual distinctions, particularly visual distinctions, static as well as in time-based distinctions" (Bonsiepe, 2019). The second aspect addresses the idea that design is accessible to everyone "who devises courses of action aimed at changing existing situations into preferred ones" (Simon, 1996, p. 111). Both come to a point where design education should question: What learning environments can afford any person a "designer's way of seeing"? (Flusser, 2013, p. 42).

Ultimately, can be deduced that the design activity is representative of the process involved in the overall mission of humanity, that is to persist in its evolution conditioned by trial-and-error with which "might in time attain and sustain a semi-divine level of exclusively artifacts-realized, creative design wisdom adequate to render the cosmic environment healthily supportive of all humanity" (Fuller, 2008, p. 13). The design definitions that reflect the purpose of leading to a design education to address that mission consider design "…the human power of conceiving, planning, and making products that serve human beings in the accomplishment of their individual and collective purposes." (Buchanan, 2001, p. 9). In the broadest sense, design can be considered human intentionality expressed through interactions and relationships, becoming then clear that,

> (…) any change that affects human intentions will redirect the entire design landscape downstream from that shift in intentionality. At first glance this design definition might sound a little broad, but if you think about it, whether we apply it to a product like a chair that expresses certain functional and aesthetic intentions of the designer, or to a monetary system that is also designed to perform a certain function based on a set of intentions, the definition holds.
>
> In the case of the chair the interactions and relationships are more focused on the different materials, production processes and spatial geometries involved, but also include the way the object, its designer, producer, distributor and user interact with the chair, and through it relate

> to each other. In the case of services and systems, for example a particular monetary system, design defines and shapes the interactions and relationships between the users of that particular medium of exchange. Design expresses and creates culture! (Wahl, 2016, p. 99)

2.3.2. Design Education within a Design Tradition

Design is the human activity of giving real existence to an idea capable of adding to the world. Accordingly, design education should focus on affording the means to organize the mind and the whole human system to provide whatever is necessary. In this context, design education is required to develop the conditions to design the designers. It involves a clear and deep awareness of the fact that humans are autopoietic, that is, living beings permanently creating and recreating themselves, as a result of their own living, and creators of the non-living/artificial, the allopoietic systems. As proposed by Nelson and Stolterman (2012), design is the first tradition of human inquiry and action, among others, "and not merely a variant of science, or art, or technology, or spirituality" therefore enabling a deeper understanding of design, within a design culture, necessary "for the release of designer's full potential and promise for generative human agency" (Nelson & Stolterman, 2012, p. 3). The authors propose a structure of foundations, fundamentals, and metaphysics, for composing their proposal of "a design way". Therefore, foundations involve the "first principles or causes of other traditions, such as science"; fundamentals are "core concepts of the design approach that can be learned and improved on through practice and reflection"; and metaphysics are the "consequences of the interaction of the fundaments and fundamentals of the design tradition, with one another and with the larger domain of human existence." (Nelson & Stolterman, 2012, p. 4).

> One of the foundations of design is its holistic character. A good design never exists in isolation. It is always part of a larger whole and is itself whole. In design, when we say that something is a whole we mean that it is a complex ensemble of relations, connections, and an underlying unifying force or principle — that which causes things to stand together — that when taken together results in emergent qualities. (Nelson & Stolterman, 2012, p. 93)

2.4. Basic Design

More than one century has passed since the creation of Basic Design at Bauhaus School of Design (1919-1933), a moment that represented the consolidation of design and the affirmation of design education worldwide.

2.4.1. Context and History of Basic Design

The *vorlehre*, *vorkurs* or preliminary course, known by its most widespread expression, Basic Design, was considered one of Bauhaus main pillars (Bonsiepe, 2012) and its most important educational innovation (Cross, 1983). BD marked a transition from a traditional technic and intellectual-focused academic education to a learning based on personal experimentation and free investigation (Sausmarez, 1995).

After the first century, BD is the most widespread expression of the original *vorkurs* and is still very important in design education (e.g., Bayirli, 2015, p. 1; Boucharenc, 2006a, p. 18). At Bauhaus, design was born inextricably intertwined with basic design within the basic course, in which, in the first phase, the presence of children's pedagogical movements and also Rudolf Steiner's anthroposophical and vitalist pedagogy are seen. In short, it is precisely the strong expressionist legacies that drive the establishment of a moment that is preliminary to real creative activities. A moment destined to release man's creative forces and, as we said, decidedly based on direct stimulation and training that expands to the faculties of the whole body (Anceschi, 2010a).

In general, BD corresponds to a propaedeutic approach in the undergraduate curricula that addresses the design fundamentals or the principles of two-and three-dimensional design (Boucharenc, 2006a, p. 1), also considered the design patterns (Bonsiepe, 2007, p. 34). Within the Art and Design-based approach, BD education can be described as an "effort of expressing the abilities and power of creativity in aesthetic level and transfer of thinking, emotions, and impressions of a person" (Besgen et al., 2015, p. 429). Some defining characteristic of BD are the aesthetic and formal exercises, exploration of colour, composition and texture, the training of the sensitivity for the aesthetical-project phenomenon, where the technical and physical factors of the materials, ergonomics, costs, manufacturing processes and even the function, are not considered (Bonsiepe, 1992, p. 159, 2012, p. 74). Abstract forms are usually preferred, as they evidence the relations between the elements in its essence, independent of the design area.

2.4.2. Classical References

The starting point for BD was at the Bauhaus School of Design, in Weimar, as result of the vision of its first director, Walter Gropius (1883-1969). Johannes Itten (1888-1967) created BD for preparing the candidates for school admission. Most of them had deficiencies resulting from previous training in arts and crafts schools and art academies, making it difficult to assess their ability and personality at the submitted works. In this sense, BD was created as a six-month mandatory course to awaken the sleeping talents, improve originality, free the imagination, and strengthen creativity of students (Itten, 1975).

Basic Design's main focus, according to Maurice de Sausmarez (1995), are the personal development and expressive capacity through: direct personal experience; a sensitive approach, more than just observation of reality; visual more than verbal; aesthetic personal decision; flexible concepts according to social and historical contexts. It aims to develop the capacity of personal research practice-based, and not theoretical-based, to an individual solution to the problem. BD emphasises the intuitive and analytic work with the materials and principles of form creation. BD should be: a mental attitude, not a method; a way of investigating, not a technique; a formal investigation but also an investigation into the origins of personal reaction to the world phenomena.

The course works the forces of the elements and their relations to create coherences. Visual coherences cannot be described or defined, can only be acknowledged when experienced through the senses. This relates to the fact that coherences are more related to neurology and psycho-physiology than with intellect (Sausmarez, 1995). The course adopted a holistic, creative and experimental methodology; and focuses elements of shape, colour, texture, light, and rhythm integrated in aesthetic and formal exercises. Thereby, it included exploring theory and practice of polar contrasts, as well as by performing relaxation and concentration exercises. These were part of a methodology for training intuition and the cultivation of self-knowledge that relied on a balance between "outward looking scientific research and technology [and]…inward looking thinking and by spiritual forces" (Itten, 1975, p. 9). It aimed for the students to: access inner experiences, perceptions and creative forces that would liberate them from preconceptions, enabling confidence in free expression and creation; discover personal unique characteristics by experimenting with different materials/mediums, thereby, easing their choice of career; and, finally, be aware of the principles of form and colour in composition for applying them in articulation both with objective and subjective modes (Itten, 1975, pp. 7–8).

The course intended to promote a higher perception, or intuition through the liberation of limiting beliefs of individual expression, thus discovering the creative, free and genuine essence in oneself. It reflected the true mission of education, that is to afford learners safe conditions for discovery and exteriorization of inner and unique talents. The development of such personal competences and abilities are presently the ones mostly valued by employers.

The *vorkurs* was influenced by Johannes Itten's spiritual beliefs and practices, thus reflecting a strand of Eastern philosophy linked to Persian Zoroastrianism and early Christianity. This aspect directly influenced the methodology and exercises of the course, namely reflecting the dualistic view of phenomena in the theory of polar contrasts. The presence of Dewey's school of thought, but also Flöebel, Montessori, and Rudolf Steiner's anthroposophical and vitalist pedagogy corresponds to a factor of innovation at high education teaching level (Cross, 1983, p. 44). However, the pedagogical innovation was abandoned a few years later, in favour of a results-based approach. Strong connections with the industry and the economy were firmed, which ensured the school's survival. By 1922, Itten's letter to Gropius reinforced his view of an educator:

> On the one hand, we must aspire to form each young man in such a way that he develops in an original way, characteristic of himself so that he continues to be a creator; on the other, we must make him come into contact with all the regular means of artistic expression, in order to configure his original and novel ideas. (Wick, 1993, p. 101)

Concurrently, László Moholy-Nagy (1895-1946) replaced Itten at the *Vorkurs* in 1923. Nagy considered that the tactile sense was the primary sources of human experience, for which he introduced specific exercises as a pedagogical introduction required for the subsequent differentiation process of optical perceptibility.

In 1928, Josef Albers (1988-1976) assumed the direction of the preliminary at Bauhaus. Albers focused the learning of creative processes by experimenting and exploring matter, according to a trial-and-error process, that is, to learn by discovering. The uses of abstract formal exercises as metaphors for understanding social and political positions (Wick, 1993, p. 160) should be highlighted in this phase.

The abstract formal exercises presented by Albers were used as metaphors for understanding social and political positions such as democracy. Thereby, the formal process using the principles of economy of the material and economy of work (valuing all parts and characteristics of the material, the positive and negative, influencing aesthetics) such as presented at the pleated material, derives an analogy with the difference between the superior and subordinate, between to dominate and to being dominated. In the same way, positive form and negative space in a 3-dimensional form take account of the characteristics of a totality that exists in the balance between two contrasting poles.

Albers' approach allows an understanding of how abstract creations, and the exploration of form can assist the practice and acknowledgement of universal principles that are present in most of the design situations. This leads to misunderstandings related to the objective of the exercises, sometimes understood as mere formalistic approaches, and, by that fact, largely criticized. Could have been this distancing from the individual a reason for the request of the students to change the Basic Course into an optional workshop in 1929 (Bonsiepe, 2019).

On the contrary to previous directors of the preliminary, Albers' position reflects the distancing from the individual. In this sense, personality development was considered an after-school task since the evolution for achieving personal goals can only be a task performed by the individual himself (Wick, 1993, p. 152). Bonsiepe highlights the intention of the Bauhaus propaedeutic course, to free and revitalize the creative capacities of the students, which he considers the also referred to as a "therapeutic role" (Bonsiepe, 1992, p. 158). However, to find oneself was considered the objective of the Bauhaus BD course, next to the consolidation of a common creative understanding, as a basis for the following teaching and learning phases (Wick, 1993, p. 68).

2.4.3. László Moholy-Nagy & the New Bauhaus of Chicago

During 1937, at the New Bauhaus of Chicago, Moholy-Nagy developed the subsequent BD model. The preliminary, later called foundation course, kept the Bauhaus general structure. Moholy-Nagy's sense of intuition as an inner visualization or insight, reflected the ingenuity of the designer, consisting of a "flashlike act" of connecting elements in a new manner. The foundation course was part of a design program that anticipated creativity, systems theory and phenomenology. These were adopted by Moholy-Nagy as "the fundamental methodological principles of the design process" (Findeli, 1990, p. 13).

The first two terms at the Institute were devoted to a *preliminary course*, obligatory to all students. It presented the fundamentals of shop work, intellectual integration, physical and biological sciences, modelling, drawing, lettering, photography, and music or literature. The objective of the course was to develop spontaneity and inventiveness, as well as to give the students a universal outlook and to make them conscious of their creative power. Moholy-Nagy's main concern "was to devise a pedagogical method that would encourage, in priority, the sense of responsibility within the students" (Findeli, 1990, p. 15), for which he developed a process-oriented education for leading the students to inner transformation, or conversion. Working on the individuality was essential to a new society that focused the designer as an integrator (Moholy-Nagy, 1947b). His pedagogic program provided the means for developing a free and responsible man capable of dealing with the coming conflicts that an electronic profit-centered age could inflict on the growing of a sociobiological economy (Findeli, 1990).

The *preliminary course* started by working the sensory stimulus and free expression, having the main objective the elimination of fear and self-consciousness in every student, the main obstacles for creativity, therefore, no judgments should be made in that learning phase (Moholy-Nagy, 1947b, p. 26). As referred by the author, "The method is to keep, in the work of the grown-up, the sincerity of emotion, the truth of observation, the fantasy, and the creativeness of the child" (Moholy-Nagy, 1947a, p. 21).

The exercises allowed the development of two predominant aspects for designers and artists: the plastic elements and the adequate tools and materials to create form. Accordingly, the elements (i.e., line, shape, colour, space, movement, texture, volume) were expressed in various media, starting with tangible two-dimensional and three-dimensional (e.g., pen, pencil, paper, clay, wood); and then, intangible (e.g., light, space and sound). After experimenting a chosen element in several different media, one media was chosen for working on fully expressive capacity and expertise. Underlying those exercises was the idea that experimenting the mechanics of work in one medium enabled to work successfully in any other medium. The process of mastering and expressing through a medium, once acknowledged by learners, can be repeated using any medium.

Findeli declares Basic Design the best pedagogic tool for developing visual intelligence in the present century. This intelligence allows the understanding and transformation of the invisible relations between the system's elements, in all its complexity (Findeli, 2001, p. 12). Quoting Moholy-Nagy, Findeli points that the one-year course

> (…) offers a test of the student's abilities,... helps shorten the road to self-experience, (...) embodies briefly the essential components of the training given in the specialized workshops, [and] gives [the student] ample opportunity to make a careful choice of his own field of specialization later. (Findeli, 1990, p. 8)

These were the first steps towards a refinement of the human being that would end up with the dissolution of oneself into the phenomenological world, for whom the course developed more an attitude than a profession (Moholy-Nagy, 1947a, p. 42).

2.4.4. The Ulm School of Design

At Ulm School (1953-1968), science and technology were reinforced in the general model of the design program, giving less space for artistic approach. Subjective ways of creating forms were replaced by rationalized processes to develop formal synthesis and where aesthetics could eventually be measured. The focus of designers turned to systems thinking as ways to address complex problems, which prioritized "interdependencies and forces that govern the behaviour of large-scale social, cultural, physical, and technological structures" (Davis, 2017, p. 30). Ulm inspired most of the post-war design education institutions that emerged around the world, except the existing English schools. The design schools of Mexico, Brazil and Argentina, but also of Japan, are direct heirs of Ulm as well are the first study plans made in Spain to implement the teaching of design and, finally, in Italy (ANECA, 2004, p. 511).

The global vision as the principle of the modern project was identified by Tomás Maldonado (Bonsiepe, 1999, p. 145), one of the Ulm school directors. Bonsiepe highlights the historical evolution of the propaedeutic course in four phases: Firstly, a general course aimed the individual expression; then, were created specialized courses for the different design areas; then, followed scientific specific propaedeutic courses; and finally, a partial abolition of the propaedeutic course by extending its content by all the years of the study programme.

In Italy, Tomás Maldonado (1922-2018) predominated over Attilio Marcolli's (1930-210) project pedagogy - *Teoria del Campo* (Marcolli, 1971, 1978). The unfamiliar language and high level of abstraction of *Teoria del Campo* (Federle, 2009, p. 22) largely contributes to being a rare reference in the literature worldwide, despite its influence on the Portuguese design education scenario (Neves, Duarte, et al., 2018, p. 138).

2.4.5. Teoria del Campo

Teoria del Campo (Marcolli, 1971) also referred to as propaedeutic course, consists of a transdisciplinary theory-methodology that aims the development of visual perception adequate for all project activities, including design. The author reinforces its adequacy for enabling a critical spirit and the ability to question and judge, essential to the project activity. In this sense, a unified perception is achieved by acknowledging the world through four successive and cumulative fields/spaces: geometric-intuitive; gestalt; topological; and phenomenological. Each field is addressed according to its structure; composition of objects; object-field interaction; and tension and movement. The implementation of such a perceptive system is afforded by the transformational geometry used in each field, respectively: the Euclidean; affine or projective; topological; and set theory. Concomitantly, each field is intended to develop the visual perception according to a four levelled typology to which corresponds a specific aesthetical expression, as devised by Bullough's typology of aesthetic expression (Marcolli, 1971, p. 6). On the other hand, Herbert Read (2007, p. 108) identifies a parallel between the four ways of perceiving: objective, physiological, associative and character, and the four basic psychic functions, proposed by Carl Jung (1875-1961): thought; sensation; feeling; and intuition. For a better comprehension of the mentioned theoretical-methodological connections involved in *Teoria del Campo*, see Table 2.

Table 2. Theoretical-methodological background of Teoria del Campo.

Perceptive fields (Marcolli)	**Transformational geometry (Marcolli)**	**Typology of aesthetic expression (Bullough)**	**Typology of visual perception**	**Basic psychic functions (Carl Jung)**
Geometric-intuitive	Euclidean	Enumerative	Objective	*Thought*
Gestalt	Affine or projective	Emphatic	Physiological	*Sensation*
Topologic	Topologic	Imaginative	Associative	*Feeling*
Phenomenological	Set theory	Organic	Character	*Intuition*

In *Teoria del Campo* (Marcolli, 1971, p. 6) the geometric-intuitive field allows the identification of the geometric physiognomy and properties of the materials, and the assigning of the concept by which it is recognized. The gestalt field highlights the different ways of viewing the object according to the multiplicity of positions/points of view. The topological field emphasizes the way in which the object relates to the individual and to all other objects with which it forms a set, an environment, a space in which to live and develop an activity. Finally, the phenomenological field relate the previous fields to a wider comprehension of the object, from the materials with which it was built; how it was designed; what are the constructive particularities; and how the various parts are connected to form a set.

2.4.6. Contemporary Basic Design worldwide

Basic Design is considered a very important component in design education (Bayirli, 2015, p. 1; Boucharenc, 2006a, p. 18) and can be found in many educational settings around the world. Most of the BD courses share essential characteristics with the Bauhaus original course, despite using more adequate formats for today's student profile and conditions (Gelmez & Bagli, 2015, p. 31). An overview of the design education in Europe - The White Book (ANECA, 2004), reported that the courses of the first semesters focused on the fundamental aspects of design, defined as Basic Design (ANECA, 2004, p. 589). They were found in the German courses, but also in Paris and Manchester, although, in the latter case, the respective contents relate to the Gestalt theory and are all applied in the project (ANECA, 2004, p. 594).

Gui Bonsiepe pointed the different possible approaches, according to a more technical-scientific or subjective-expressive character, sometimes bringing disagreement about how the basics of design should be lectured. Besides enabling the learning of the design fundamentals to be further developed in subsequent years, the propaedeutic course also intends to level the knowledge of the students coming from the previous school years; to overcome the lack of visual literacy, in the sense of sensitize the perceptive capacities to the visual perceptive environment (Bonsiepe, 1992, p. 158).

The propaedeutic course tends to be seen detached from the subsequent years of the design study programme. To surpass some possible disconnection, Bonsiepe suggests the creation of a "transition point between the propaedeutic course – in which are practiced the non-applied exercises – and the following courses, in which, on the opposite, the project work concentrates on applied practical and functional exercises" (Bonsiepe, 1992, p. 159). Since 1975, the first edition of *Teoria e Prática do Design Industrial* persists the question relating the way to surpass the need to connect the faculties acquired during the first year of the study programme, based on non-applied exercises, and the projects in the following years. One possible solution can be to balance the relation between non-applied project exercises and practical exercises along the several years of the study programme in a way that they can be reduced along the time, in such a way that exercises non directly applied in the project are still present.

As other authors, Bonsiepe suggested to amplify the content of the propaedeutic course to all the years of the study programme, thus following the example of what already had been implemented in the *Ulm’s Hochschule für Gestaltung* (Bonsiepe, 1992).

In Turkey, the BD addresses the fundamental principles of two-dimensional (2D) and three-dimensional (3D) design, studied through hands-on experiences. “BD has a long tradition in Turkey extending to the 1960s, and its principles were established upon Gestalt psychology, General Systems Theory, and Set Theory in the early 1970s” (Cindioglu et al., 2021, p.4).

In Jordan, BD is more than a course for preparing learners for subsequent years of design studies. It fills a gap in the field of art and design general education. All schools of architecture have invested in a first-year curriculum that focuses on the basic concepts of composition and manual skills. The foundational course is taught in both semesters, at German Jordanian University (GJU), “Basic Design” and “Introduction to Architectural Design”, respectively, in the first and second semesters, emphasizes the architectural aspects of design (Yaghan & Ashour, 2008). BD in India has a two-year duration.

> In the first year, the design elements and principles are introduced with its grammar developing concurrently. In second year, the students understand basic design through various tangible and intangible channels of creativity. The aim of the curriculum is to make students’ sensitive to the quality of space. (Parashar, 2010, p. 526)

Relative to the Portuguese HE context, contemporary versions of BD persist under different designations, such as Project in Basic Design; Form and Colour; Introduction to Design; Laboratory of Matter and Form (Neves, Dias, et al., 2018, p. 7668), just to name a few (Neves, Dias, et al., 2018, p. 7667).

Knauer’s recent approach to the principles and methodology of design, called Transformations (2008), is an opportunity for clarifying the transformational processes constitutive of Basic Design pedagogy. According to 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 (Findeli, 1990).

Looking in depth Knauer's Transformations, "basis structures consist of formal processes that the imagination's images can develop 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" (Knauer, 2008, p. v). 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 as "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.

The previously referred verbal citations link the abstract models to any known real situation: specific objects, forms, functions, daily life scenarios, and were suggested as a powerful instrument for the teaching and learning at 3D Design Lab.

2.4.7. The Portuguese scenario

In Portugal, recent studies identified the permanence of BD in the HE system (Neves, Dias, et al., 2018) and revealed the presence and evolution of the course during the 50 years of the Institute that pioneered the design education in Portugal, IADE (Neves et al. 2018). Synchronic and diachronic analysis are presented below.

The pioneers of Basic Design

In the Portuguese context, the first pedagogical experience addressing specifically BD was undertaken by the designer and, at the time, teacher at EADAA - *Escola de Artes Decorativas António Arroio*, Daciano da Costa (Neves et al., 2018). Between 1962 and 1964 he conducted a private Basic Design course in his own "atelier" (Costa, 2001). In the scope of BD, the design problems at hands in the atelier were analysed according a Bauhausian structure: the genesis of the form was based on an experimental didactics informed by Itten's theories of colour and form and also influenced by Laszlo Moholy-Nagy and Josef Albers (Souto, 2001). In 1977, Daciano da Costa, also lectured BD at *Cursos Artísticos da Fundação Ricardo Espírito Santo Silva* (Costa, 2001).

The case of IADE's Design School

The year of 1969 marks the foundation of *Instituto de Arte e Decoração – IADE*, frequently considered the pioneer institution for teaching design in Portugal. This spread idea relates to the large contribution of IADE to the opening of the debate around the discipline, provided by courses and seminars (Almeida, 2009). António Quadros (1923-1993), philosopher, writer, and teacher, was the founder of the Institute, who invited the painter Lima de Freitas (1927-1998) to be the first director of IADE. In 1973 António Quadros replaced Lima de Freitas until 1992, one year after his death, passing the school direction to his son António Roquette Ferro.

The initial three-year study programme, named Interior Decoration Course, aimed the teaching of art and decorative courses. Some of original teachers, besides António Quadros, were the painters Lima de Freitas, Manuel Lapa, Rafael Calado, Eduardo Nery and Manuel Costa Cabral. Also, the architects Francisco Keil do Amaral, Manuel Costa Martins and Júlio Gil taught at the initial course, as well as the sculptor Graça Costa Cabral. The designer John David Bear arrived in 1970, which promoted changes at the pedagogical orientations at the institute, namely by replacing the expression *decoration* by *design*. The integration of the new concept was also due the influence of the French designer, Claude Ternat and the connections with the Milanese Scuola Politecnica di Design. In close cooperation with its director, Di Salvatori, IADE organized seminars about design since the academic year 1973-74. Bruno Munari and Attilio Marcolli oriented seminars at IADE in the seventies and eighties, largely contributing to the pedagogical options at the institute. During 1977, Bruno Munari worked with the school's teachers analysing IADE's programme "resulting in flagrant improvements in the curriculum, its content and methods." (IADE – Instituto de Artes Visuais, Design e Marketing, 1989, p. 18).

Basic Design at IADE

Basic Design course at IADE was consistently integrated in the curricular programmes of the design study programmes from 1979 until 2002-03. According to Neves et al. (2018), due the implementation of the Bolonha Process (1999), the annual courses were divided in two biannual courses, therefore BD was separated in two courses: Morphologic Analysis adopted the content of BD related to form; and Chromatic Analysis adopted the content related to colour.

In the academic year of 2010-2011 the mentioned courses were replaced by Tri-dimensional Design and Bi-dimensional Design, respectively. Four years later, in 2015, IADE became a University Institute: Instituto de Arte, Design e Empresa – Universitário (IADE-U). Some of the modifications then occurred in the design study programme involved the replacement of the mentioned courses for 3D Design Laboratory and 2D Design Laboratory, respectively, are kept until the present moment.

During the 50 years of IADE's existence, a few aspects relating Basic Design presence can be highlighted:

- In 1990, the 12 topics initial structure of Basic Design study plan, adopted the present model (i.e., that includes contents; objectives; and methodology).
- In the 1989 BD course, the term creativity appears for the first time, maintaining and reinforcing its presence along the subsequent years.
- The courses 3D Design Laboratory and 2D Design Laboratory, present different pedagogical approaches: 3D Design Laboratory adopts abstract and exploratory approaches to mostly 3D creation, but also 2D; and 2D Design Laboratory adopts applied exercises that include typographic and colour content in 2D creations.
- Breathing and relaxation exercises are not present in any version of BD Curricular Unit.
- The topic "textures" was only present in the BD course until 2002-03.

2.4.8. Reformulating Basic Design worldwide

New directions towards improving BD courses around the world have been reported. At a Turkish HE Institution, METU - *Middle East Technical University,* a study intended to set a foundation for further improvements in the course (Bayirli, 2015, p. 101). Problems reported by the students pointed to difficulties in: transfer of knowledge and skills to projects in subsequent years; thinking in three-dimensional way or in developing forms; developing a sense of aesthetics; and apporting sufficient theoretical knowledge to the design project. Alternative ways of surpassing these issues could be involving BD instructors in some stages of product design processes, in the studios, which also could benefit remembering and retaining basic design knowledge. To solve the transition problem from handcraft to computer environment, it is suggested the inclusion of computer and digital design tools in the earlier stages of design education. To surpass the inability in internalizing BD in terms of three-dimensional issues, more three-dimensional form exercises in BD could be delivered. Workshops dedicated to form development of products to the students in the subsequent years could help surpass these difficulties. Specific activities could involve exemplifying and analysing functional objects in terms of BD issues to determine how the principles of BD are perceived and implied in manufactured objects. This could help students understand and reflect BD issues applied to product design process by establishing a relation with real products rather than abstract works (Bayirli, 2015).

The reformulation of the basic course at IADE will be further detailed in the next section but, in general, the reformulation, which was proposed by Fernandes (2011), applied a theoretic frame derived from the systemic, complexity and constructivism theories.

An international survey to design teachers pointed that BD should be integrated over the full length of the academic program (Boucharenc, 2006a, p. 19) concurring with Findeli's suggestion (Findeli, 2001, p. 16). One possible solution would be linking the fundamentals of design knowledge, as covered in BD, with the practical aspects of design practice. BD is, in fact, considered "equally significant in both freshmen as well as senior years… [playing]… a profound role throughout the whole education setting, from lectures, form creation process, to design criticism and assessments and even expanding its worth into professional practice" (Rahardja & Adiwijaya, 2011, p. 925).

The reformulation of Basic Design at IADE

The presence of BD at IADE´s Design study programmes was evidenced by a diachronic analysis conducted by Neves et al. (2018). As already mentioned, a consequence of the biannual scission was the distribution of the content topics previously addressed at the Basic Design Course, by the newly created Morphologic Analysis and Chromatic Analysis. In the context of Morphologic Analysis, a revision of the basic course was undertaken, for which contributed the methodology developed by Fernandes (2011). The courses Tri-dimensional Design and 3D Design Laboratory that succeeded Morphologic Analysis kept almost intact the study programme developed during the 2002-03 basic course revision. In this moment were adopted the content topics from Gui Bonsiepe's proposals to integrate a pedagogical practice that transformed the inherited exercises from "the "Basic Design" course… [into]… "modelling paths of abstract object systems" (Fernandes, 2011, p. 97).

Morphologic Analysis contextualized the creation of a pedagogical concept for assisting the learning process, identified with the notion "product's informational prospective"

(Fernandes, 2011, p. 20). This concept acts as a pedagogic tool for leading the learners to performing the adequate competences, thereby manifesting the learning has occurred. Learning involves, in this sense, a cognitive transiting by four different orders of recursions. Those are divided in two groups, one closely related to bodily and instinctual determinations where the act is more spontaneous and intuitive; and another involving processes that occur in a prominently mental way, thus linked to rational and reflective determinations. The first group is related to intuitive and spontaneous actions, like the ones involved in most of our routines and habits. If somehow a disturbance occurs that demands a different procedure to continue operating, a transition to the second order of recursions is made, where the observer and the object are simultaneously constituted to enable surpassing the impasse. Consequently, reflection and analysis of the phenomena may also be involved, which is made in a third order recursion. In the fourth order is attained the autonomy and creativity, thus affording project capacity, responsibility, and freedom. The concept reflects a specific mechanism for accelerating the passage through orders of recursion in the language (Fernandes, 2011, p. 19), thus promoting the learning.

The *Laboratório de Design 3D* aims the development of a sensitivity to the technological and aesthetic phenomena of the 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 reinforced throughout three exercises, with increasing levels of complexity, according to the three first perceptive fields of Marcolli's project pedagogy (i.e., geometric-intuitive; gestalt; and topological). Each exercise is evaluated in three categories, with precedency: technique, analytic and aesthetic (Neves & Duarte, 2015a).

Rooted in BD, the methodology currently adopted at the *Laboratório de Design 3D* (Lab D3D) course, which has been taught at IADE, was revised and updated by Fernandes (Fernandes, 2011). The current course corresponds to a cross propaedeutic training to three main project areas: graphic, product and interior design. It aims the incorporation of a process for generating complex systems by recursively applying trial and error while promoting students' engagement in creating three-dimensional (3D), hand scale, abstract forms, mainly by using hand skills.

2.4.9. Digital Technology in Basic Design

In current design education, digital technology is considered essential to the transformation of educational models and processes which, more than ever, are required to include hybrid and blended learning alternatives, facilitating remote learning. From this perspective, digital technology is expected to increase globally, also in BD pedagogical practices (Colucci, 2011). In this sense, some studies have been pointing to the need for restructuring BD traditional philosophy of “learning by doing”, usually relying almost exclusively in bodily natural competences, from a Bauhaus-oriented education, to accommodate the digital technology paradigm (Uysal & Topaloğlu, 2017). Most specifically, the post-Bauhaus tradition and pedagogy inspired Monache and Rocchesso (2014) to develop a systematic exploration of sounding objects with a basic sonic interaction design. Previously, new didactics based on multimedia synaesthesia were applied in BD by Riccò et al. (2003). The approach to synaesthesia in BD was considered in multimedia didactics by Guerini (2001), which presented the rational of a sensorial laboratory for experimenting the mechanisms of interaction between the senses in specific contexts involving sound, sight and touch. Adding “(…) to the pure perceptive factor, there was the influence of other aspects (physiological, psychological, emotional, cultural and ideological) that are often determinant on our way to perceive, establishing relations with objects all around us” (Guerini, 2001, p. 162).

The studies relating BD and synaesthesia point also to the possibility of creating synesthetic experiences using VR for affording holistic learning tools (Liu, 2020; Liu et al., 2019). The artificial combinations of senses are allowed with the use of the mentioned digital technological medium, which can replace or add the human body natural condition.

Virtual Reality in Basic Design

Studies that address the influence of VR on BD refer the design process creativity in BD education. Design process creativity was compared using immersive and non-immersive Virtual Design Environments (VDE). Immersive VDEs enabled the participants a higher sense of involvement during the design process, as well as more motivation and a higher state of flow, thus provoking a higher design process creativity, when compared with the non-immersive VDE. In the immersive VDE participants also experienced body involvement, which facilitated participants’ design process creativity (Obeid, 2019, p. iii).

In another study, the usability of a VR system was analysed during problem-solving in BD in the context of interior architecture activities for architecture students (Özgen et al., 2019). The usability of VR in design education was through an experimental study conducted during problem-solving activities in basic design education. The same task was performed by two groups of students (one used conventional paper and the other used VR application). Once applied the Technology Acceptance Model (TAM) the study revealed no significant differences in the levels of Perceived Usefulness (PU) and Perceived Ease of Use (PEU). However, in the group that used the VR application, the Intention to Use (IU) and Perceived Enjoyment (PE) presented higher values. The study concluded that VR can strongly enhance problem-solving, in the given context, considering it a "promising and complementary tool in Basic Design education" (Özgen et al., 2019, p. 15).

Whereas the mentioned studies add to the discussion about the introduction of computer-based design tools in BD, they also stress the importance "for design students to develop perceptual motor skills such manual modelling skills and skill in the manipulation of materials" (Boucharenc, 2006a, p. 18), in order to develop a personal understanding and relationship with materials. In this respect, Sorby (1999) highlights the benefit of the manual-visual articulation for the spatial visualization, an essential competence for designers that VR systems can amplify (Sik Lányi et al., 2003, p. 293). Though advocated the use of computers to design 2D, Wucius Wong 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" (1995, p. 239).

2.5. Education

In the lifelong learning educational paradigm, designer education is increasingly a continuous process in which moments of non-formal, formal and informal learning are interspersed. The educational aspect of the institutionalization of design in Portugal, in the period between 1965 and 1974, clearly identifies these levels (Almeida, 2009).[1]

[1] Vítor de Almeida, in his doctoral thesis entitled: "The institutionalization of Portuguese Design between 1959 and 1974" identifies the moments of informal, non-formal and formal learning in that period. Informality marked the years between 1959, and 1964, of learning oriented mainly in the workshops. In the "informal phase of the workshops" it was learned in a work context, and in close collaboration between disciple/master. An iconic example of this informal teacher figure was

Higher Education is considered the basis of the professional training of designers, granting them certification for the profession. However, the other modes of learning (i.e., informal and non-formal), where take place learning experiences difficult to occur in the formal structure of higher education institutions, significantly complement and consolidate the designer education. In a near future, formal design education could open to such an articulation thus enabling students' direct experiences in professional context, leading to wiser decisions relating the choice of the design area to embrace in the future.

2.5.1. Pedagogy versus anthropagogy

Like the first versions of BD education that aimed to meet the full development of human beings during the process, the training of young adults who attend the HE system are considered, above all, human beings. Regardless of age, education at this level must contemplate the development of human being. Therefore, the most adequate expression to designate educational work in its essence is not pedagogy, as it refers only to the education of children and young people. Being a child implies being human first, therefore, the expression proposed by Manuel Ferreira Patrício - anthropagogy, is what better reflects the science and art, theory and practice, of leading the human being to the fullness of himself. Here are included the processes, methods, techniques and tools by which this learning takes place. As pointed by Manuel Patrício Gouveia "what is essential in education (…) does not concern only the child, but every human being as such (…). We understand, therefore, that the Science of Education should not be called Pedagogy but, more strictly, Anthropagogy"[2] (Cracel et al., 2014, p. 14). Quoted by Magalhães (2004, p. 14) Manuel Ferreira Patrício stresses:

> Education is a process that concerns the totality of the human and the totality of men and not just children and young people. Therefore, the science of education has to be the science of this totality (…). All men must be educated, they must be educated in everything, they must

Frederico George, in whose studio many of the first Portuguese designers were trained, (e.g., Daciano da Costa and António Sena da Silva). A second "non-formal training course" phase followed, between 1965 and 1974. This was characterized by being an organized and systematized educational activity developed outside the ateliers and corporations, such as free courses for professional specialization, workshops, seminars, and training sessions. Finally, formal education in design began to take place through attendance at courses given at educational institutions with public certification.

[2] Translated by the authors

> be educated using all modes of education. It is education in the maximum of its human universality. It is an ideal in keeping with the most profound ethical, social and political requirements of our century. In my understanding, the adequate name to fully embrace this ideal is Anthropagogy, that is: theory and practice of the formation of man in his humanity; theory and practice of the education of man in his full humanity. [3]

We thus reinforce the education of the human being, as a whole and throughout the entire life, at all ages, which includes young adults in the beginning of a formal higher education process.

2.5.2. Higher Education System

Learning Outcomes

Learning Outcomes (LOs) can be considered descriptions of abilities expected from learners as result of learning experiences. They are also identified as: academic goals; expected results; and learning objectives. A set of knowledge, skills, and competencies are embodied in the LOs, which also include values, beliefs, and attitudes to be achieved by students (Dias, 2017). From the point of view of the student, LOs are intentions to act on a specific object and are thereby identified as Intended Learning Outcomes (ILOs) (Biggs & Tang, 2007). Three levels of ILOs need to be aligned: graduate attributes; program outcomes; and course outcomes. The impact of the Bologna Declaration on the HE system established learning outcomes as a key instrument (OECD, 2012), which becomes a familiar and relevant expression among all the actors in the system.

LOs constitute the "Framework for Qualification of European Higher Education", aligning assessment methodologies and curricula design. This European common structure allows the comparison between study programs and HE institutions in Europe. The several qualification levels of the Framework are defined according to a learning outcomes approach (González & Wagenaar, 2008). It is emphasized the importance of the LOs for directing the design of learning activities by focusing on the required changes on the learners' performance; in establishing guidelines for content, instruction and evaluation; in explicitly recognizing what is to be learned; and in delivering to learners what exactly is to be accomplished.

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[3] Manuel Ferreira Patrício, Breve Notícia sobre Estudos de Pedagogia Portuguesa Contemporânea, in I Encontro de História da Educação em Portugal. Comunicações, Lisboa, Fundação Calouste Gulbenkian, 1988, pp. 239 - 245

Constructive alignment theory

The Constructive Alignment Theory (Biggs & Tang, 2007) aims the enhancement of teaching and learning focusing on the outcomes, referenced as Outcomes-Based Teaching and Learning (OBTL).

Intended Learning Outcomes - ILOs are statements describing what and how a student is expected to learn after exposure to teaching, according three levels: graduate attributes, in institutional level; degree program level; and course level (Biggs & Tang, 2007, p. 64). The LOs specify the cognitive levels of performance that students should achieve in a certain content topic by detailing the actions that should occur. The Structure of the Observed Learning Outcome (SOLO) taxonomy presents a list of appropriate verbs in two main categories: quantitative and qualitative, which correspond to the low and high cognitive levels, originating low and high levels of understanding respectively. A pre-structural level precedes four other levels of understanding and it stands for no existing competence, for which is absent from the SOLO table of verb (Biggs & Tang, 2007, p. 80). The low-level outcomes involve simple and quantifiable verbs: unistructural level and multi-structural level. As for the quality phase, the high-level outcomes are relational and extended abstract. SOLO taxonomy provides a systematic way of describing the growing in complexity of the student's performance when mastering an academic task.

2.6. Virtual Reality

Myron Krueger mentions that "Virtual Realism is an art form, a sensibility, and a way of living with new technology" (Heim, 1998, p. ix), being virtual reality (VR) a technology that can be applied to every human activity and can be used to mediate in every human transaction. Since you are completely immersed in the virtual world, virtual reality constitutes a new form of human experience—one that may be as important to the future as film, theatre, and literature have been to the past. Its potential impact is so broad that it may define the culture that results from its use. As a consequence, the concept of virtual reality will be as widely used as a metaphor as it is in practice. (Heim, 1994, p. vii)

With the new artificial experiences made possible by VR, as convincing as the real ones, an ontological (reality) shift was accentuated and with it came an opportunity to redefine ourselves as human beings in co-evolution with our own creations. As mentions Heim, "An ontological shift is a change in the world under our feet, in the whole context in which our knowledge and awareness are rooted." (Heim, 1994, p. xiii). It is also important to acknowledge that "the personal and social consequences of any medium- that is, of any extension of ourselves - result from the new scale that is introduced into our affairs by each extension of ourselves, or by any new technology" (Mcluhan & Lapham, 1994, p. 9).

2.6.1. Virtual Reality and Virtual Environments

Over 50 years have passed since the first recorded implementation of a digital VR system, a flight simulator created to train American military pilots, in 1966 (Kavanagh et al., 2017). In 1991 VR was firstly used for gaming purposes; in 1995 was released a VR based game with a Head Mounted Display- HMD, all failing in the commercial level.

VR involves the use of 3D synthetic worlds (i.e., virtual environments - VEs) that can allow the users to experience the artificial phenomenon with the quality and intensity once thought to be unique of real life. To be able to provide such an experience, a high sense of presence (i.e., the sense of being there, inside the VE) is required. Thus, according to the Triangle of VR proposed by Burdea and Coiffet (Burdea & Coiffet, 2003), the computer-based simulation can be classified according to its ability to provide the user levels of interaction, immersion and imagination. 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 behaviour. Immersion has to do with the real-world isolation level offered by the system, which can be not immersive, semi-immersive or immersive. Imagination is a variable that depends on the user and his/her willingness to be "deceived" but also from the quality of the narrative/storytelling presented.

Other factors are also known as playing a role on the sense of presence, such as the number of human senses being stimulated, and the VR induced symptoms and effects (e.g., nausea, eye fatigue, disorientation, proficiency with navigation techniques) (Sharples et al., 2008). A combination of all these factors can be used to characterize the VR simulation in the so-called "Virtual Continuum" (Milgram et al., 1995), which is a line that spans from the real-world environment to a pure virtual environment, with Augmented Reality (closer to the real environment) and Augmented Virtuality (closer to the virtual environment), in-between. 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 VEs, the immersive VR systems (e.g., using head-mounted displays or CAVE[4]) can facilitated the evaluation of more advanced aspects of interaction with the world, as behaviours or emotional responses with good ecological validity (e.g., Rebelo et al., 2011). To assess perceptions of space, shape, size, among others, non-immersive desktop VEs may be sufficient, in which the environments or objects are generated and displayed by 3D modelling software (e.g., 3D Studio Max; Sketchup Pro).

VR technology is used in a broad range of scopes, such as entertainment (e.g., games, movies), education and training (e.g., simulations, serious games), collaborative work, and therapy (Lanyi, 2012). The technology allows the generation of phenomena, alternative experiences to reality, enabling innovative pedagogical approaches (Schank, 2011). Due to the constant evolving of the technology, its potential to the teaching-learning process at the present times, is far from being totally unveiled (Jones, 2013).

2.6.2. Virtual Reality for Education and Training

The importance of VR in the educational context is reinforced every year, despite being far from consistently adopted in the area (Kavanagh et al., 2017). VR studies involving educational contexts point to effectiveness of this relation for facilitating the learning of abstract concepts (Abdelaziz et al., 2014); improves learning outcomes and has positive effect on the cognitive and affective domains of the learners (Lee, 2011; Merchant et al., 2014); and promotes the transfer of learning (Bossard et al., 2008) by encouraging of diverse ways of thinking through the observation from multiple perspectives (Lee, 2011). From motivation to deep learning and long-term retention, VR has been revealing positive impact on education and training (Kavanagh et al., 2017). However, the limitations to the technologies, as well as to the costs and logistics still imped the widespread of VR digital technologies. Kavanagh et al. (2017) identified that “the majority of researchers use virtual reality to increase the intrinsic motivation of students, and refer to a narrow range of factors such as constructivist pedagogy, collaboration, and gamification in the design of their experiences” (Kavanagh et al., 2017, p. 85), indicating that few research revels consistent pedagogical background.

[4] CAVE - Cave Automatic Virtual Environment, is a highly immersive virtual reality environment enabled by three or more projectors directed to the walls of a room-sized cube.

The previous study identified that 51% of the research cases addressing the impact of VR on education are from the HE context (2017). Despite the potential of VR and the growing research interest in applying it in education, Radianti et al. (2020) mention the unexplored application of immersive VR for higher education purposes considering, particularly, the immersive head-mounted displays (HMDs). The authors highlight three key elements as a foundation for successful VR-based learning: the learning contents, the VR design elements, and the learning theories, being the latest "not often considered in VR application development to assist and guide toward learning outcomes" (Radianti et al., 2020a, p. 1). The authors identified that "the evaluation of educational VR applications has primarily focused on usability of the VR apps instead of learning outcomes and immersive VR has mostly been a part of experimental and development work rather than being applied regularly in actual teaching" (Radianti et al., 2020a, p. 1), showing a still very low maturity of the field.

When using VR technologies, some factors can reduce the sense of presence, ending up conditioning the acquisition of competences: the poor graphical quality of VR; the awareness when using VR; and the individual personality traits (Radianti et al., 2020). These add to the well-known barriers to the use of VR for learning, such as nausea, dizziness, and other physical symptoms, to the limitations related to the technology, such as the display resolution and the cables connecting the system devices.

2.6.3. Virtual Reality in Design Education

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 (Abdelaziz et al., 2014). One study outlined the effectiveness of VR technology-based instruction (i.e. games, simulation, virtual worlds) in improving learning outcome gains (Merchant et al., 2014), reinforcing the already known positive effect of VR-based learning environments on the cognitive and affective domains of learners (Lee, 2011). Games and Gamification are emergent technologies largely impacting world education, allowing strategies that stimulate collaborative work, creativity and motivation in students and teachers (Monteiro & Barbosa, 2014). As highlighted in the NMC Horizon Report: 2014 Higher Education Edition (Johnson et al., 2014), those technologies were to be adopted in the high educational context within a few years, 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 (Johnson et al., 2014, p. 42). According to another 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 (Carvalho et al., 2014). 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 (Dalgarno & Lee, 2010). In the educational setting, VR allows observation from multiple perspectives, which encourages diverse ways of thinking, (Lee, 2011, p. 2) and it can be used to promote the transfer of learning (Bossard et al., 2008).

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 (D'Souza et al., 2011). It showed that VR interface considerably increased logical, kinaesthetic 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 (D'Souza et al., 2011).

The potential of an immersive VR tool was used for creating architectural spaces in a study by Angulo and Velasco (2014), which allowed the authors to conclude that VR improves the performance and increased the critic and collaborative spirit between the students. VR has "immense visualization and interaction possibilities [and has an] enormous potential to support creative design in the early conceptional phases of product development" (Adenauer et al., 2013, p. 125). Lau and Lee (2015) affirm that VR can enhance students' learning experiences by enabling a heuristic and highly interactive simulated virtual environment. An important fact that should be considered by educators is that "Being explorative and fun are essential parts of students' learning experiences in virtual reality" resulting in motivated students to explore creative ideas (Lau & Lee, 2015, p. 3).

2.6.4. Teaching with Virtual Reality

It has been highlighted the need for training teachers in using AR/VR for educational contexts (Fernandez, 2017). Deepening the subject, a research conducted by Bernardo and Duarte (2020, p. 580) points to a lesser familiarity of teachers with VR or Mixed Reality (MR) when compared to other existing digital technology (such as desktop or laptop computers, smartphones and digital tablets, and wearables and smart home devices). The same authors also stress that the post-pandemic future of design education considers the features of VR and Multi-User Virtual Environments (MUVEs), for which design educators show interest in learning and using (Bernardo & Duarte, 2020, p. 584).

2.7. Exploring the connections between Virtual Reality for learning the design fundamentals, at 3D Design Lab

At 3D Design Lab course in IADE graduation in design, the exercises consist of activities triggered by minimum action programs, directed towards the delivering of an object/structure, that is, a process by which capacities are acquired. During the process, the challenges that emerge are overcome by the regular feedback, comments and critics to the students' work. These are decisive for the adequate change of behaviour to occur relating the structure, thus revealing the new competences (Fernandes, 2011). The activities proposed and the feedback (e.g., metaphors, analogies) are important pedagogic instruments that conduct the students' actions on creating the structure, and consequently, on the structure itself. Instead of using verbal cues, Knauer suggest using visual "citations" (2008). Knauer's operative aesthetic consists of searching the form, not by the function of any semiotically finished object, but by a constantly increasing of aesthetics, on an abstract form empty of content.

The content topics are introduced in the dialogue with students about the structure being created rather than previously exposed equally to all the students. In the initial phase of each exercise, no visual examples are given, avoiding the natural tendency of novice students to rush to stereotype results, that is, objects semiotically recognized from the daily life. To overcome this tendency, sequences of actions are proposed, as a strategy for developing a wider understanding of the creation and transformation process, and not to fixate on a specific result. According to Fernandes's methodology (2011), no specific competence is required for the exercises, allowing any supposed unprepared student to overcome difficulties as they arrive. 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 mentioned methodology consists of an increasing growth of complexity within the 3 moments/exercises, provided by: the application of successive levels of perception of space suggested by Marcolli (1998); the approaching of 2D before 3D (Bonsiepe, 1992, 161; Wong, 1995); 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. This last component is related with the general quality of the visual effects that, when recognized by the students themselves and their peers, are referred as interesting, beautiful, and so on. Aesthetic performance is rooted on technical and analytic performance, resuming them all, being the result of an intense effort to master the manual and intellectual process. A reflexive instrument is requested at the end of each exercise, which consists of a visual analysis of the whole process.

In this learning context, the use of VR-based tools could favour the acquisition of different points of view of their abstract objects, enabling enriching the visual perception of the students. It could also provide the opportunity to manipulate the structures, in terms of core operations, i.e., symmetry operations can foster a higher engagement and better learning. Consequently, the content topics would also be acknowledged in different and more varied contexts, and learning would be improved. In the beginning of the exercises students don't feel connection with the abstract creations. Gradually, the interest and motivation increase, sometimes set off by verbal suggestions of "what it could be", providing the emotional impulse to act-reflect. The imagination is then more easily released to deliver the manually crafted objects. However, that kind of approach is not effective for all students, with a few persisting in a disengaged attitude. Also, others declare a personal missing enthusiasm for manual tasks. In this situation, setting a new environment, like VR, can be beneficial for what is known, as different environments provoke distinct cognitive action types (Gul, 2009, p. 615), reaching out also other learning styles and motivations. 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 with more difficulties with the traditional process. According to Lee (2011, p. 44), 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) (Lee, 2011, p. 44).

A protocol analysis experiment conducted with expert designers revealed that in digital design environments perceptual actions seem to be more common 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 (Gul, 2009, p. 621). Therefore, we deduce that VR technology could afford the opportunities to engage more students in the perceptual actions related with different contexts and scenarios, thus positively affecting motivation, enthusiasm and eventually, performance results.

Adopting ergonomics terminology in product design, a scenario incorporates the 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 (Fulton Suri & Marsh, 2000; Nardi, 1992). Thus, exposure to different scenarios will allow potential users to present their ideas and/or questions about their 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 behaviour in critical situations of interaction with a product or system. Different media can be used to implement these scenarios (e.g., narratives written with or without illustrations; video narratives; drama with real characters or interactive virtual environments). Being able to foresee multiple different scenarios and/or concrete applications for the abstract objects is essential for developing more complex and interesting forms. Abstract design principles, which is the focus of 3D Design Lab, if extended to different scenarios and contexts (real or imagined) could widen the understanding of the abstract principles.

Affording a virtual environment, as a space for manipulation of students' structures, could be beneficial for effective learning and engagement to all students, particularly to those that have more difficulties in performing tasks usually accomplished in the traditional way. Lastly, for the future designer, by being provocative of emotions and actions (Bonsiepe, 2011, p. 53), VR can also benefit through experiences requiring the perception of student's own emotions and of the others, at different levels of immersion and different situations/scenarios.

2.8. Chapter Summary

Along the chapter, both concepts of Basic Design and Virtual Reality were addressed with the objective of identifying the potentiality of the connection for delivering innovate approaches to design education, and specifically for learning the design fundamentals.

From the general ideal brought by Myron Krueger, virtual reality "is the first intellectual technology that permits the active use of the body in the search for knowledge" (Heim, 1994, p. viii), making it a potential ally for integrating learning tools in BD, considered in its origins, an articulation between body, mind and spirit. Mcluhan and Lapham add to this perspective: "As the age of information demands the simultaneous use of all our faculties, we discover that we are most at leisure when we are most intensely involved, very much as with the artists in all ages" (1994, p. 383). The intense involvement provided by the simultaneous use of all human faculties, points to the centrality of the sense of presence both in VR and BD (for learning, in general). Therefore, it is likely that a VR-based tool for learning BD can impact positively some aspects of the BD, similarly to what has been occurring in other areas.

The studies about the relation between VR and BD, in this recently created research topic highlighted the limited research that can be extended to design education, in general (Özgen et al., 2019, p. 15).

Specifically in the context of 3D Design Lab was suggested how VR could contribute to learning the design fundamentals. Future steps of research can test the students' reaction to the inclusion of VR-based tools for learning the abstract concepts. Particularly, can be assessed if and how such tools contribute to learn the abstract concepts, when observed and explored in virtual environments, using different scenarios. Finally, can be assessed how VR-based tools impact the students' motivation towards the exercise.

2.9. References

Abdelaziz, M., Riad, A., & Senousy, M. B. (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), 320–328.

Adenauer, J., Israel, J. H., & Stark, R. (2013). Virtual Reality Technologies for Creative Design. In A. Chakrabarti (Ed.), *CIRP Design 2012* (pp. 125–135). Springer London. https://doi.org/10.1007/978-1-4471-4507-3_13

Almeida, V. (2009). *O Design em Portugal, um Tempo e um Modo. A institucionalização do Design Português entre 1959 e 1974* [Doutoramento, Faculdade de Belas Artes, Universidade de Lisboa]. http://repositorio.ul.pt/bitstream/10451/2485/2/ulsd059655_td_Tese_Victor_Almeida.pdf

Anceschi, G. (2010). Design di base: Fondamenta del design. *Il Verri 'Newbasic'*, *43*. http://www.ilverri.it/index.php/la-rivista-del-verri/edizione-dal-1996/newbasic-detail

ANECA. (2004). *Bibro Blanco. Títulos de grado en Bellas Artes/Diseño/Restauración*.

Ângulo, A., & Velasco, G. V. de. (2014). *Immersive Simulation of Architectural Spatial Experiences*. 495–499. https://doi.org/10.5151/despro-sigradi2013-0095

Anita Rahardja & D. Rio Adiwijaya. (2011). Basic Design is Indeed for Expert. *Humaniora*, *2*(2), 925–931. https://doi.org/10.21512/humaniora.v2i2.3138

Bayirli, Ü. (2015). *Evaluation of Basic Design education at METU department of Industrial Design* [Master]. Graduate School of Natural and Applied Sciences of Middle East Technical University.

Bernardo, N., & Duarte, E. (2020). *Design, Education, and the Online Tech- Pandemic*. *13*(03), 10.

Besgen, A., Kuloglu, N., & Fathalizadehalemdari, S. (2015). Teaching/Learning Strategies Through Art: Art and Basic Design Education. *Procedia - Social and Behavioral Sciences*, *182*, 428–432. https://doi.org/10.1016/j.sbspro.2015.04.813

Biggs, J., & Tang, C. (2007). *Teaching For Quality Learning At University* (Edição: 3). Open University Press.

Bologna Process Committee (1999). *Joint declaration of the European Ministers of Education convened in Bologna on 19 June 1999*. (The Bologna Declaration). ec.europa.eu/education/policies/educ/bologna/bologna.pdf

Bonsiepe, G. (1992). *Teoria e prática do design industrial: Elementos para um manual crítico* (1992nd-1ª ed portuguesa ed.). Centro Português de Design.

Bonsiepe, G. (1999). *Del Objeto a la Interfase*. Ediciones Infinito.

Bonsiepe, G. (2007). The Uneasy Relationship between Design and Design Research. In R. Michel (Ed.), *Design Research Now: Essays and Selected Papers* (pp. 25–39). Birkhäuser Architecture.

Bonsiepe, G. (2011). *Design, Cultura e Sociedade*. Edgard Blucher.

Bonsiepe, G. (2012). *Design como Prática de Projeto*. Edgard Blucher.

Bonsiepe, G. (2019). *On the heteronomy of design in a post-utopian age* [Draft].

Bossard, C., Kermarrec, G., Buche, C., & Tisseau, J. (2008). Transfer of learning in virtual environments: A new challenge? *Virtual Reality*, *12*(3), 151–161. https://doi.org/10.1007/s10055-008-0093-y

Boucharenc, C. (2006). Research on Basic Design Education: An International Survey. *International Journal of Technology and Design Education*, *16*(1), 1–30.

Buchanan, R. (2001). Design Research and the New Learning. *Design Issues*, *17*(4), 3–23. https://doi.org/10.1162/07479360152681056

Burdea, G. C., & Coiffet, P. (2003). *Virtual Reality Technology* (2 edition). Wiley-IEEE Press.

Carvalho, A. A., Araújo, I., Zagalo, N., Gomes, T., Barros, C., Moura, A., & Cruz, S. (2014). Os jogos mais jogados pelos alunos do Ensino Básico ao Ensino Superior. In A. Carvalho, S. Cruz, C. Marques, A. Moura, & I. Santos (Eds.), *Atas do 2º Encontro* *sobre Jogos e Mobile Learning* (pp. 74–84). Universidade do Minho. Instituto de Educação. Centro de Investigação em Educação (CIEd).

Cindioglu, H. C., Gursel Dino, I., & Surer, E. (2021). Proposing a novel mixed-reality framework for basic design and its hybrid evaluation using linkography and interviews. *International Journal of Technology and Design Education*. https://doi.org/10.1007/s10798-021-09707-0

Colucci, K. (2011). What role will technology play in the future of design education. In *Icograda Design Education Manifesto 2011* (pp. 63–67). http://toolkit.icograda.org/database/rte/files/PR_IEN_Manifesto2011_webres.pdf

Costa, D. da. (2001). *Curriculum Vitae*.

Cracel, M. da C., Dias, G. D., & Correia, M. N. (2014). *Quatro Ontagogos de Portugal. António Sérgio, Almada Negreiros, Adolfo Coelho e Ramalho Ortigão* (J. C. Casulo, Ed.). Estratégias Criativas.

Cross, A. (1983). The educational background to the Bauhaus. *Design Studies*, *4*(1), 43–52. https://doi.org/10.1016/0142-694X(83)90007-8

Dalgarno, B., & Lee, M. (2010). What are the learning affordances of 3-D virtual environments? *British Journal of Educational Technology*, *41*(1), 10–32.

Davis, M. (2017). *Teaching Design: A Guide to Curriculum and Pedagogy for College Design Faculty and Teachers Who Use Design in Their Classrooms*. Allworth.

Dias, D. (2017). Learning Outcomes in European Higher Education. In P. Texeira & J. Shin (Eds.), *Encyclopedia of International Higher Education Systems and Institutions* (pp. 1–5). Springer Netherlands. https://doi.org/10.1007/978-94-017-9553-1_317-1

D'Souza, N., Yoon, S.-Y., & Islam, Z. (2011). Understanding design skills of the Generation Y: An exploration through the VR-KiDS project. *Design Studies*, *32*(2), 180–209. https://doi.org/10.1016/j.destud.2010.07.002

Federle, G. (2009). *Basic Design La formazione al design nella Scuola secondaria* [Doutoramento, Università Ca' Foscari Venezia]. http://dspace.unive.it/bitstream/handle/10579/1016/Tesi_Federle_2010.pdf?sequence=1

Fernandes, R. (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.* (http://eprints.ucm.es/12198/1/T32379.pdf). Universidade Complutense de Madrid.

Fernandez, M. (2017). Augmented Virtual Reality: How to Improve Education Systems. *Higher Learning Research Communications*, *7*(1), 1–15.

Findeli, A. (1990). Moholy-Nagy's Design Pedagogy in Chicago (1937-46). *Design Issues*, *7*(1), 4–19. https://doi.org/10.2307/1511466

Findeli, A. (1994). Ethics, Aesthetics, and Design. *Design Issues*, *10*(2), 49–68. https://doi.org/10.2307/1511628

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

Findeli, A. (2018). The Metamorphosis of the Designer: A Prerequisite to Social Transformation by Design. In M. Förster, S. Hebert, M. Hofmann, & W. Jonas (Eds.), *Un/Certain Futures—Rollen des Designs in gesellschaftlichen Transformationsprozessen* (1. Edition, pp. 104–113). transcript Verlag.

Flusser, V. (2013). *The Shape of Things: A Philosophy of Design*. Reaktion Books.

Flusser, V. (2018). *O mundo codificado: Por uma filosofia do design e da comunicação*. Ubu Editora.

Fuller, R. B. (2002). *Critical Path* (2nd Revised edition edition). Saint Martin's Griffin,U.S.

Fuller, R. B. (2008). *Grunch of Giants*. Design Science.

Fulton Suri, J., & Marsh, M. (2000). Scenario building as an ergonomics method in consumer product design. *Applied Ergonomics*, *31*(2), 151–157. https://doi.org/10.1016/S0003-6870(99)00035-6

Gelmez, K., & Bagli, H. (2015). Learning from Students: Reflections from personal magazines in basic design course. *Design and Technology Education: An International Journal*, *20*(1). http://ojs.lboro.ac.uk/ojs/index.php/DATE/article/view/2019

González, J., & Wagenaar, R. (Eds.). (2008). *Tuning Educational Strucures in Europe. Universities contribution to the Bologna Process. An introduction* (2ª). Publicaciones de la Universidad de Deusto.

Gu, N., Gul, L. F., & Williams, A. (2010). Methods for evaluating 3D Virtual Worlds in Design Education. *International Design Conference - Design 2010*, 1259–1266.

Guerini, S. (2001). *Il Corpo Risponde. Le sinestesie nella didattica multimediale* [Licenciatura, Politecnico di Milano]. https://issuu.com/silviaguerini/docs/il_corpo_risponde_silvia_guerini_ca

Gul, L. F. (2009). Studying the Impact of Immersion on Design Cognition. *Computation: The New Realm of Architectural Design: 27th ECAADe Conference Proceedings*, 615–622.

Heim, M. (1994). *The Metaphysics of Virtual Reality*. Oxford University Press USA.

Heim, M. (1998). *Virtual Realism*. Oxford University Press.

Itten, J. (1975). *Design and Form: Basic Course at the Bauhaus* (Revised edition edition). Titles Supplied by John Wiley & Sons Australia.

Johnson, L., Adams Becker, S., Estrada, V., & Freeman, A. (2014). *MC Horizon Report—2014 Higher Education Edition*. http://www.nmc.org/pdf/2014-nmc-horizon-report-he-EN.pdf

Jones, D. (2013). An Alternative (to) Reality. In M. Childs & A. Peachey (Eds.), *Understanding Learning in Virtual Worlds* (pp. 1–20). Springer.

Kavanagh, S., Luxton-Reilly, A., Wuensche, B., & Plimmer, B. (2017). A Systematic Review of Virtual Reality in Education. *Themes in Science and Technology Education*, *10*(2), 85–119.

Knauer, R. (2008). *Transformation. Basic Principles and Methodology of Design* (1st ed.). Birkhäuser GmbH.

Lanyi, C. (Ed.). (2012). *Applications of Virtual Reality*. InTech.

Lau, K. W., & Lee, P. Y. (2015). The use of virtual reality for creating unusual environmental stimulation to motivate students to explore creative ideas. *Interactive Learning Environments*, *23*(1), 3–18. https://doi.org/10.1080/10494820.2012.745426

Lee, E. A. L. (2011). *An investigation into the effectiveness of virtual reality-based learning* [Phd, Murdoch University]. http://researchrepository.murdoch.edu.au/4070/

Liu, Y. (2020). Future Step of Basic Design: Between Synaesthesia Didactic and Virtual Learning. In F. Tosi, A. Serra, A. Brischetto, & E. Lacono (Eds.), *Design for Inclusion, Gamification and Learning Experience* (FrancoAngeli).

Liu, Y., Riccò, D., & Calabi, D. (2019). A synaesthetic learning approach to cave. *3rd International Conference on Environmental Design*, 273–280.

Magalhães, C. (2004). *O pensamento antropagógico de Agostinho da Silva* [Doutoramento]. Universidade do Porto, Faculdade de Letras.

Marcolli, A. (1971). *Teoria del Campo—Corso di educazione alla visione* (1998th, 17ªed ed.). Sansoni Editore.

Marcolli, A. (1978). *Teoria del Campo 2—Corso di metodologia dalla visione* (1991st, 3ª ed. ed.). Sansoni Editore.

Maturana R., H., & Varela G., F. (2004). *De máquinas y seres vivos* (6th ed.). Lumen.

Mcluhan, M., & Lapham, L. H. (1994). *Understanding Media: The Extensions of Man* (New Ed edition). MIT Press.

Merchant, Z., Goetz, E. T., Cifuentes, L., Keeney-Kennicutt, W., & Davis, T. J. (2014). Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis. *Computers & Education, 70*, 29–40. https://doi.org/10.1016/j.compedu.2013.07.033

Meyer, M. W., & Norman, D. (2020). Changing Design Education for the 21st Century. *She Ji: The Journal of Design, Economics, and Innovation, 6*(1), 13–49. https://doi.org/10.1016/j.sheji.2019.12.002

Milgram, P., Takemura, H., Utsumi, A., & Kishino, F. (1995). Augmented Reality: A class of displays on the reality-virtuality continuum. *Proc. SPIE 2351, Telemanipulator and Telepresence Technologies*. Telemanipulator and Telepresence Technologies. https://doi.org/10.1117/12.197321

Moholy-Nagy, L. (1947a). *The New Vision and Abstract of an Artist* (1928 Fourth revised Edition 1947 edition). George Wittenborn Inc.

Moholy-Nagy, L. (1947b). *Vision in Motion*. Wisconsin Cuneo Press.

Monache, S., & Rocchesso, D. (2014). Bauhaus Legacy in Research through Design: The Case of Basic Sonic Interaction Design. *International Journal of Design International*

Journal of Design [Online], *8*(3). http://www.ijdesign.org/ojs/index.php/IJDesign/article/view/1543/657#3

Monteiro, R., & Barbosa, H. (2014). Challenges Game: Um jogo dinamizador do processo de ensino. In A. Carvalho, S. Cruz, C. Marques, A. Moura, & I. Santos (Eds.), *Atas do 2º Encontro sobre Jogos e Mobile Learning* (pp. 74–84). Universidade do Minho. Instituto de Educação. Centro de Investigação em Educação (CIEd).

Nardi, B. A. . A. (1992). The use of scenarios in design. *SIGCHI Bull*, *24*(3), 13–14.

Nelson, H. G., & Stolterman, E. (2012). *The Design Way: Intentional Change in an Unpredictable World : Foundations and Fundamentals of Design Competence*. Educational Technology.

Neves, A., Dias, D., & Duarte, E. (2018). As Basic Design promotes the Design Learning: Featuring the Portuguese Higher Education setting. *ICERI2018 Proceedings*, 7663–7671. https://doi.org/10.21125/iceri.2018.0376

Neves, A., & Duarte, E. (2015a). Using Virtual Environments in Basic Design Education. In E. Duarte, C. Duarte, & F. Carvalho Rodrigues (Eds.), *Senses & Sensibility'15: Design as a Trade Proceedings of the UNIDCOM/IADE 8th International Conference* (pp. 273–280). IADE - Creative University / Edições IADE.

Neves, A., & Duarte, E. (2015b). Using Virtual Environments in Basic Design Education. In E. Duarte, C. Duarte, & F. Carvalho Rodrigues (Eds.), *Senses & Sensibility'15 Proceedings* (pp. 273–280). IADE - Creative University / Edições IADE.

Neves, A., Duarte, E., & Dias, D. (2018). Basic Design at IADE: Drawing the line. In E. Duarte (Ed.), *Design Doctoral Conference'18: TRANSgression. Proceedings of the DDC 5th Conference* (pp. 137–144). Edições IADE.

Obeid, S. (2019). *The Influence of Virtual Reality on Design Process Creativity in Basic Design Education* [Master]. Department of Interior Architecture and Environmental Design, İhsan Doğramacı Bilkent University.

OECD. (2012). *Assessment of Higher Education Learning Outcomes AHELO. Feasibility Study Report, vol 1 – Design and Implementation* (volume 1).

Özgen, D. S., Afacan, Y., & Sürer, E. (2019). Usability of virtual reality for basic design education: A comparative study with paper-based design. *International Journal of Technology and Design Education*. https://doi.org/10.1007/s10798-019-09554-0

Parashar, S. (2010). Basic Design Studio, an ongoing research. *Proceedings of the 2010 International Conference on Architectural Research The Place of Research/ The Research of Place*, 523–536. http://www.google.pt/url?sa=t&rct=j&q=innovation_in_design_education&source=web&cd=1&cad=rja&ved=0CCwQFjAA&url=http%3A%2F%2Fwww.allemandi.com%2Funiversity%2FInnovation_in_Design_Education.pdf&ei=er0MU4S6Ka3y7Abu94DABA&usg=AFQjCNHYtFt7J0ltBnv9q6XOx-5LTeCdyw&bvm=bv.61725948,d.bGQ

Radianti, J., Majchrzak, T. A., Fromm, J., & Wohlgenannt, I. (2020). A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. *Computers & Education*, *147*, 103778. https://doi.org/10.1016/j.compedu.2019.103778

Read, H. (2007). *Educação pela Arte*. Edições 70.

Rebelo, F., Duarte, E., Noriega, P., & Soares, M. M. (2011). Virtual Reality in Consumer Product Design: Methods and Applications. In Waldemar Karwowski, Marcelo M. Soares, & Neville A. Stanton (Eds.), *Human Factors and Ergonomics in Consumer Product Design: Methods and Techniques* (pp. 381–402). CRC Press.

Riccò, D., Belluscio, A., & Guerini, S. (2003). Design for the synesthesia. Audio, visual and haptic correspondences experimentation. *Proceedings of the Senses and Sensibility in Technology –Linking Tradition to Innovation through Design*, 159–164.

Sausmarez, M. de. (1995). *Diseño básico: Dinámica de la forma visual en las artes plásticas*. Gustavo Gili.

Schank, R. C. (2011). *Teaching Minds: How Cognitive Science Can Save Our Schools*. Teachers College Press.

Sharples, S., Cobb, S., Moody, A., & Wilson, J. R. (2008). Virtual reality induced symptoms and effects (VRISE): Comparison of head mounted display (HMD), desktop and projection display systems. *Displays*, *29*(2), 58–69. https://doi.org/10.1016/j.displa.2007.09.005

Sik Lányi, C., Lányi, Z., & Tilinger, A. (2003). Using Virtual Reality to Improve Space and Depth Perception. *Journal of Information Technology Education*, *2*, 291–303.

Simon, H. A. (1996). *The Sciences of the Artificial* (3rd edition). MIT Press.

Sorby, S. A. (1999). Developing 3-D Spatial Visualization Skills. *Engineering Design Graphics Journal*, *63*(2), 21–33.

Souto, M. H. (2001). Daciano da Costa e o ensino do Design em Portugal. In *Daciano da Costa Designer* (Fundação Calouste Gulbenkian, pp. 34–41).

Uysal, V. Ș., & Topaloğlu, F. (2017). Bridging the Gap: A Manual Primer into Design Computing in the Context of Basic Design Education. *International Journal of Art & Design Education*, *36*(1), 21–38. https://doi.org/10.1111/jade.12048

Wahl, D. C. (2016). *Designing Regenerative Cultures*. Triarchy Press Ltd.

Wick, R. (1993). *La pedagogía de la Bauhaus* (B. B. Álvarez, Trans.; Edición: edición). Alianza.

Wong, W. (1995). *Fundamentos del diseño* (4ª). Gustavo Gili.

Yaghan, M., & Ashour, R. (2008). The Battle of Grids: Preparing first year students for their upcoming design studies in Jordan. In *Designing Design Education Proceedings: Vol. Part II* (pp. 210–223). Designtrain Congress. http://www.elia-artschools.org/images/products/17/part_2.pdf

Chapter III

(...) the world does not consist only of the rigorous profiling of geometric laws and casual chains; The universe does not contain only what is quantifiable; The qualitative, the synchronic, the illogical and even the "impossible" are as real as the rest.[5]

Lima de Freitas

3. Experimental study for developing and testing a Virtual Reality-based tool, in Basic Design

3.1. Abstract

Basic Design remains an unexplored field regarding the input of the new technologies (e.g., Virtual Reality - VR) in the teaching-learning process, to which it could introduce innovative aspects. As result of the already acknowledged positive impact of VR-based tools for educational contexts, we expected that it could help overcoming some difficulties noticed by the first-year design students. This leaded us to the implementation of an experimental study conducted during 2016 Spring semester, in the 3D Design Laboratory[6] course at IADE Design School. During the experimental study we developed a VR-based tool for teaching and learning Basic Design topics and, subsequently, test the tools and procedures to assess the impact of the VR tool in the teaching-learning process.

In a first moment a VR-based tool was developed. We intended not only provide students the opportunity to interact with 3D structures, but also to explore the technology we had at hand. For this we used a quasi-experimental methodology and compared two groups of students (control and experimental). The control group was exposed to a conventional teaching method

[5] Free translation from the original: (…) o mundo não consiste apenas no perfil rigoroso das leis geométricas e dos encadeamentos casuais; o universo não encerra somente o que é quantificável; o qualitativo, o sincrónico, o ilógico e até o “impossível” são tão reais como o resto.

[6] Free translation from the original - Laboratório de Design 3D.

(i.e., verbal content plus static pictures) and the experimental group to a hybrid method (i.e., verbal content plus VR-based tool). We also created tools for measuring the influence of the VR-based tool on the identified dependent variables: self-perceived creativity level; self-perception of creativity barriers; self-perceptions of motivation; and student's performance.

In a second moment, we assessed the emotional response of the students during the experience. For this purpose we used a tool developed by Pieter Desmet for measuring emotional responses to products, the Product Emotion Measurement Instrument (PrEmo). The results revealed enthusiastic reactions from the students, whether in engaging moments of discussion about the exercise, or while exploring the abstract structures in different scenarios. However, difficulties related with the implementation of the procedure during the semester were noticed, urging modifications.

3.2. Chapter Introduction

Due to the digital technologies advent, current generations of design students constantly expect new teaching methodologies that, in turn, demand new learning environments and adequate teaching methods, prompting new pedagogical approaches (Gu et al., 2010). Since Basic Design is one of the main components in design education (Findeli, 2001; (Boucharenc, 2006b; Anceschi, 2010a; Cetinkaya, 2014), new approaches should be expected in this discipline too.

3.2.1. Basic Design pedagogy

Basic Design was born at Bauhaus School (1919-33) for addressing the initial formative period of the designer using a holistic, creative, and experimental methodology with respect to fundamental principles of design. It was built on the dichotomic pedagogical principle of "intuition and method" or "subjective experience and objective recognition" to help develop an attitude more than professional skills (Droste, 1992). Despite the many changes occurred since the beginning of its existence, BD is internationally implemented and adapted to the present times (Cetinkaya, 2014), being considered the best pedagogic approach for developing visual intelligence in the present century (Findeli, 2001). Characteristics of the aesthetic and formal exercises are dependent from the exploration of colour, composition and texture, though, most of the technical and physical factors are not taken into account (e.g., materials, ergonomics, costs, manufacturing processes and the function) (Bonsiepe, 2012).

3.2.2. Basic Design-rooted curricular unit

Laboratório de Design 3D (Lab D3D) was the course selected to host this study. The methodology adopted at the Lab D3D course is detailed in section 2.4.7 of this document. But, in short, the course involves the creation of manually crafted three-dimensional (3D) abstract forms. Functional aspects of the objects, as well as many other constrains of a design project (e.g., technical, and physical factors of the materials, ergonomics, costs, manufacturing processes), are not considered. Some of the design variables (e.g., colour and texture) are also excluded from the program of Lab D3D. The course focuses on developing a sensitivity to the technological and aesthetic phenomena and project ability (Bonsiepe, 2012, p. 77), over the incorporation of design patterns: field structure; reference mark; elementary parts; elementary motif; combinatorial; modularity; patterning; symmetry/ asymmetry; formal coherence; structural consistency; systemic; complexity; simplicity; maximum diversity with the minimum repertoire; among others. According to the currently adopted program, these concepts are repeated throughout three exercises. Nevertheless, it can be seen that Lab D3D remains an unexplored discipline regarding the application of new technologies (e.g., Virtual Reality - VR) in the teaching-learning process (Neves & Duarte, 2015b).

3.2.3. Virtual Reality digital technology for teaching-learning

The teaching and learning of design contents have undergone a significant transformation in recent years, driven by the integration of technological tools in the classroom. This shift is not only limited to traditional in-person classes but also extends to remote education. Technological advancements have not only enhanced the accessibility of design education but have also revolutionized the way students engage with and understand design concepts. But there is a gap on how to use the technological tools to enriched basic design education, linking theory and practice, and facilitating effective learning in both physical and virtual classrooms.

In traditional classroom settings, technology has become an indispensable part of design education. Tools like digital drawing software, 3D modeling applications, and multimedia presentations have empowered instructors to convey complex design concepts with greater clarity and engagement. Students can experiment with digital tools to create designs, providing them with immediate feedback and opportunities for iteration. Furthermore, technology has enriched the learning experience by enabling virtual field trips and real-time access to design resources from around the world. Virtual tours of architectural marvels, art galleries, and design studios can transport students to far-off locations, immersing them in different design perspectives without leaving their desks.

One remarkable example of technology transforming design education is the integration of 3D printing. In basic design courses, students can conceptualize their ideas in digital spaces and then bring them to life through 3D printing. This hands-on experience allows students to bridge the gap between theoretical design principles and practical application. They can witness the physical manifestation of their creations, gaining a deeper understanding of design's tangible impact. The advent of remote education, driven by global events like the COVID-19 pandemic, has necessitated further exploration of technology in design education. Virtual learning environments, video conferencing tools, and collaborative platforms have enabled students and instructors to connect seamlessly across distances. In this context, technology has not only become a facilitator of education but also a means of fostering a sense of community and collaboration among learners. In remote education, virtual design workshops have gained prominence. In these workshops, students can collaborate on design projects in real-time, sharing screens, sketches, and ideas through video conferencing and digital whiteboards. Instructors can provide instant feedback and guidance, creating an interactive and dynamic learning environment.

While the integration of technology in basic design education can offer numerous benefits, it also comes with challenges. Access to technology and digital resources may not be equitable for all students, requiring institutions to address issues of accessibility and provide necessary support. Moreover, instructors must adapt their teaching methods to effectively engage students in virtual settings, ensuring that the essence of hands-on design learning is not lost.

Virtual reality (VR) technology is rapidly emerging as a powerful tool in the realm of education. Basic design courses could benefit from this technology as well. Its immersive nature and interactive capabilities offer unique potentialities for enhancing the teaching and learning of fundamental design principles.

One of the key strengths of virtual reality is its ability to transport students into immersive learning environments. In basic design education, this means that students can step into digital spaces that replicate real-world design scenarios. They can explore structures, walk through them, or engage with interactive design installations, all from the comfort of a VR headset. In this work, we delve into the transformative potential of virtual reality in basic design education, exploring how this technology can inspire creativity, provide practical experience, and foster a deeper understanding of design concepts.

In short, we consider that: i) The use of technological tools can enhance basic design education; ii) Virtual reality can provide immersive learning environments, hands-on design experiences, and interdisciplinary collaboration opportunities; iii) VR can improve presentation skills by enabling immersive design presentations; and iv) VR is poised to revolutionize basic design education by fostering creativity and excellence.

Half a century of digital Virtual Reality has allowed some understanding of its growing importance in many areas of society and, in education as well. In the learning context, VR is reinforced for learning abstract concepts (Abdelaziz et al., 2014), but also can improve learning outcomes, with a positive effect on the cognitive and affective domains of the learners (Merchant et al., 2014), (Lee, 2011). VR can also be used to promote the transfer of learning (Bossard et al., 2008) by adding the encouragement of diverse ways of thinking through the observation from multiple perspectives (Lee, 2011, p. 2). Accordingly, our research intends to deepen the understanding of the contribution of VR for design education, more precisely, in the Basic Design context.

3.2.4. Theory of Cognitive Flexibility

The Theory of Cognitive Flexibility, based on the constructivist learning theory deals with the acquisition of advanced level of knowledge in complex and little-structured domains, as well as the transfer of knowledge to new situations (Carvalho, 2011). Thus, according to its authors, the learning process should create the opportunities for opening the range of possible uses of a concept. This would enable its use in more different ways, consequently affecting flexibility for solving new situations (Spiro et al., 2007).

Despite the well-known benefits of VR in the learning process, the pedagogical approach in Lab D3D is still based on a conventional non digital methodology that mostly relies on hand skills. However, some limitations were observed, that might be surpassed with the contribution of VR. Thus, in this study, and supported by the Cognitive Flexibility Theory, two semi-immersive VR-based tools (3D wall screen projection) were developed, aiming to present the students new situations where the morphogenetic process and related concepts (already introduced in previous exercises) can be perceived and comprehended. This study presents a VR-based methodology that can contribute to Basic Design education.

3.3. Methodology

The effect of the VR tool on the learning process was assessed with several questionnaires:

- *Creativity Level* - For measuring the Creativity Level, one questionnaire was applied in two moments: before the exercise 1 (i.e., moment 1) and after the exercise 3 (i.e., moment 4). The questionnaire was answered on a 5-points Likert type scale, in which 1 stands for not creative and 5 for extremely creative. The questionnaire can be found in Annex D.
- *Barriers to Personal Creativity* - For measuring the Barriers to Personal Creativity (Self-perception of Creativity), one questionnaire was applied in four moments: before exercise 1 (i.e., moment 1) and after exercise 1, 2 and 3 (i.e., moments 2 to 4). The questionnaire was answered on a 5-points Likert type scale, in which 1 stands for totally disagree, and 5 for totally agree. The questionnaires can be found in Annexes D, E, F and G.
- *Self-perception of Motivation* - For measuring Self-perception of Motivation, one questionnaire was applied in the end of each of the three exercises, (i.e., in moments 2 to 4). The questionnaire was answered on a 5-points Likert type scale, in which 1 stands for totally disagree, and 5 for totally agree. The questionnaire can be found at Annexes E, F and G.

3.3.1. Quasi-experimental design

Participants

Two groups of students aged between 18 and 24 years old, were randomly assigned to two groups, which were named “Experimental group” (group that used the VR tool) and “Control group” (group that did not use the VR tool). The participants were enrolled in the 1st year of the design course at IADE, attending the discipline of Lab D3D. We tried to organise the groups as homogeneously as possible regarding age and gender, within the closed sample resulting from the composition of the class, which we couldn’t change (i.e., the experimental group has 12 male and 23 female; and the control group, 10 male and 13 female). Students were also levelled in terms of performance knowledge, since the first exercise serves this purpose. The experimental group was exposed to a hybrid method (i.e., verbal and VR-based tool) and the control group was exposed to a conventional method (i.e., verbal and static pictures). However, due to various reasons (e.g., dropping out, changing classes, absence or failure to hand in work) at the end of the procedure the sample subject to analysis was reduced to 10 students per group.

Design of the study

In the first part of the research we employed a quasi-experimental methodology, which is frequently adopted in educational settings, where it is common to work with convenience samples (Creswell, 2013), as in our case. Similar approaches have been applied to evaluate the effects of the VR-based instructions on K-12 (i.e., school period between Kindergarten and the secondary, in the north American system) and higher education settings, using also a learning outcome measure (Merchant et al., 2014). For example, quasi-experimental methodology was used to determine the most effective type of 3D experiences on pupil learning and achievement, and for measuring the value and impact of these experiences (Bamford, 2011). 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.

To determine the effect of the VR tools on the teaching-learning process we used a mixed design, in which the groups (control group vs. experimental group) are the between-subjects factor and the exercises the within-subjects factor. The dependent variables are Perception of Barriers to Personal Creativity Inventory (mentioned also as Self-perception of Creativity), Creativity Level, Self-perception of Motivation, and Performance, which are detailed in the next topic - Stimuli. The study flow-chart (Figures 2 and 3) depicts the sequence of phases/exercises and the measures gathered.

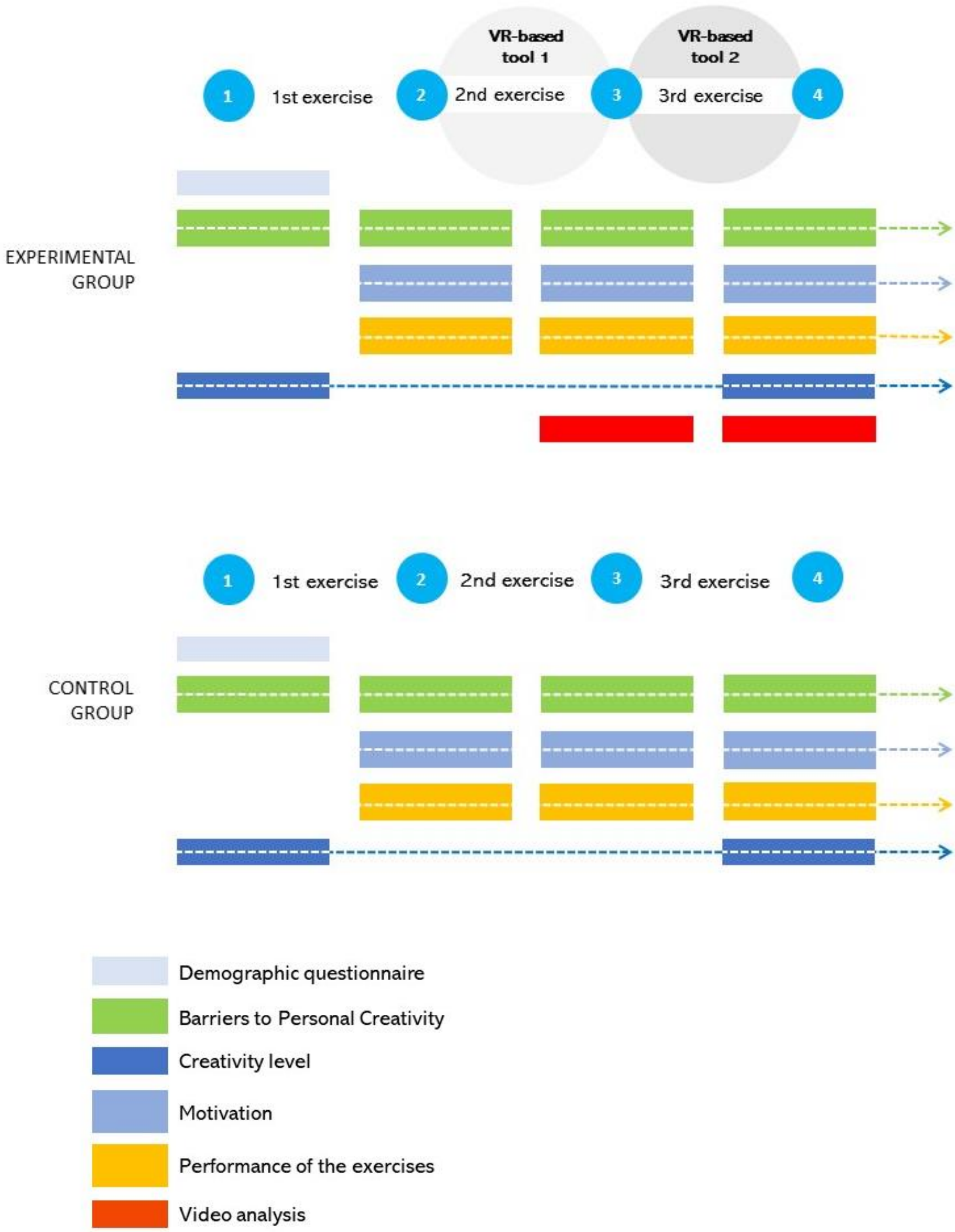

Figure 2. Quasi-experimental design within groups.

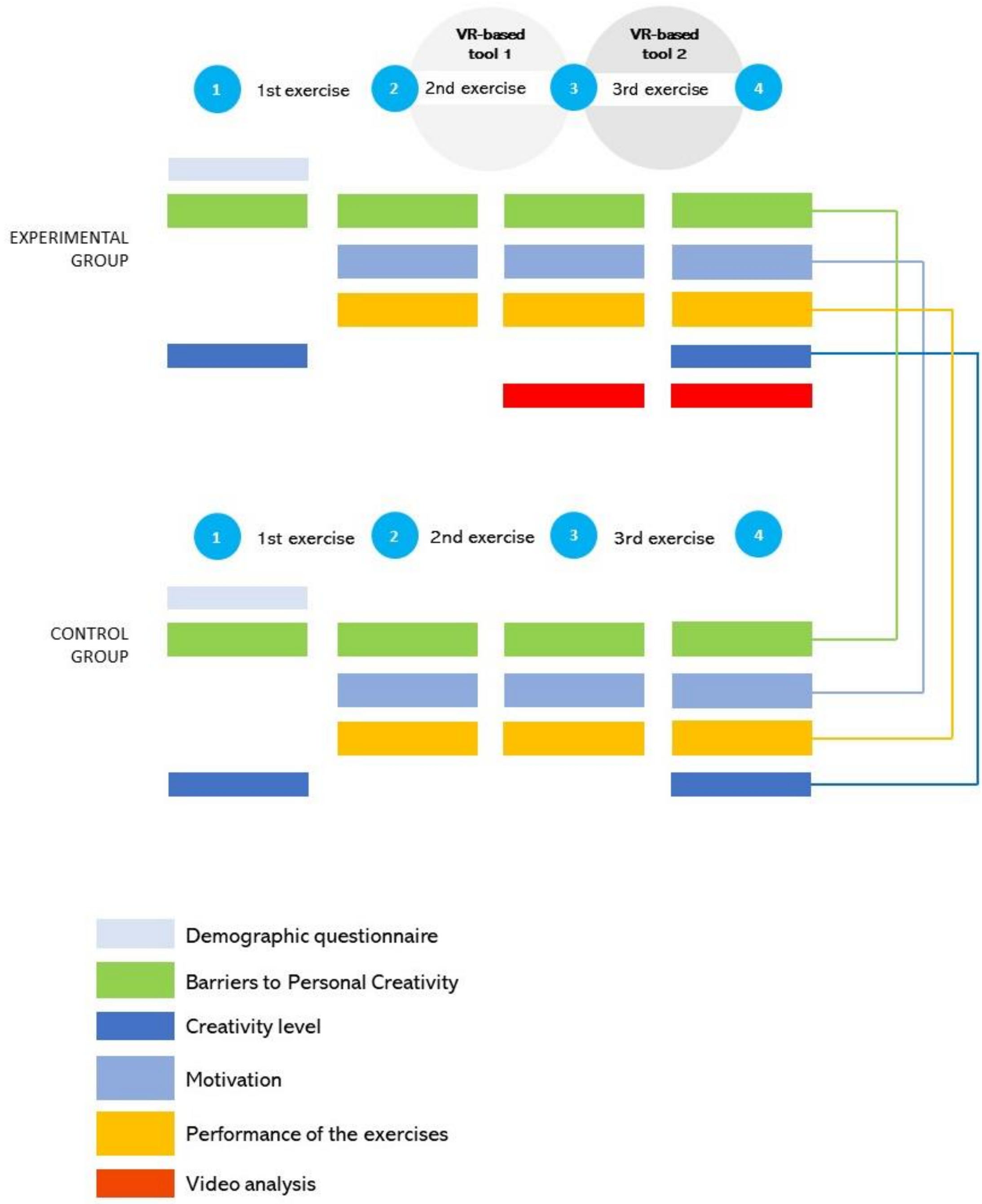

Figure 3. Quasi-experimental design between groups.

The students replied to questionnaires in four moments of data collection:

- Moment 1 (before the 1st exercise):
  - Demographic data (see Annex C, page 23)
  - Creativity Level and Perception of Barriers to Personal Creativity (see Annex D, page 27).

- Moment 2 (after concluding the 1st exercise):
    - Self-perception of Creativity and Motivation (see Annex E, page 35).
- Moment 3 (after the 2nd exercise):
    - Self-perception of Creativity and Motivation (see Annex F, page 45).
- Moment 4 (last moment of data collection):
    - Self-perception of Creativity and Motivation
    - Creativity Level (see Annex G, page 55).

Stimuli

Three exercises were given for one semester, coherent with a learning by doing process. Each one required mastering a medium, i.e., technical competency for creativity expression and aesthetic quality. All exercises should be solved individually and each one should take five weeks (6 hours per week) to accomplish. The briefings for each exercise were presented to the students every five-week period. General verbal orientations and visual examples were provided and commented by all. Further details were highlighted along the five-week practice in feedback moments.

With a growing level of complexity, the exercises aim the development of a morphogenetic creation process with formal coherence. Thus, in the Exercise 1 and 2 students worked from parts to totalities, in the Exercise 3 they first explored the totality of the form to get to the constitutive elements.

The evaluation of the exercises reflected the increasing of complexity, thus, each exercise assessed three categories of competences: technique, analytic and aesthetic. At the end of each exercise a visual analysis of the whole process was requested. Complementarily, a practical examination was required for assessing the performance in Exercise 1 and posters and/or videos for the Exercises 2 and 3. All exercises require no pre-concept but, instead, and along the whole procedure, the aesthetic features and qualities of the volumes afford suggestions for different possible uses in the social-cultural context, highlighting for this purpose what could be, what could do and how could it do, in different contexts and scales.

Exercise 1

The main objective of Exercise 1 was to introduce the morphogenetic process for modularity and pattern creation using 2D form generation. Two modular systems were created, which apply the process for formal coherence (Bonsiepe, 2012) and the principle for maximum diversity with the minimum repertoire, among others (see Figure 4).

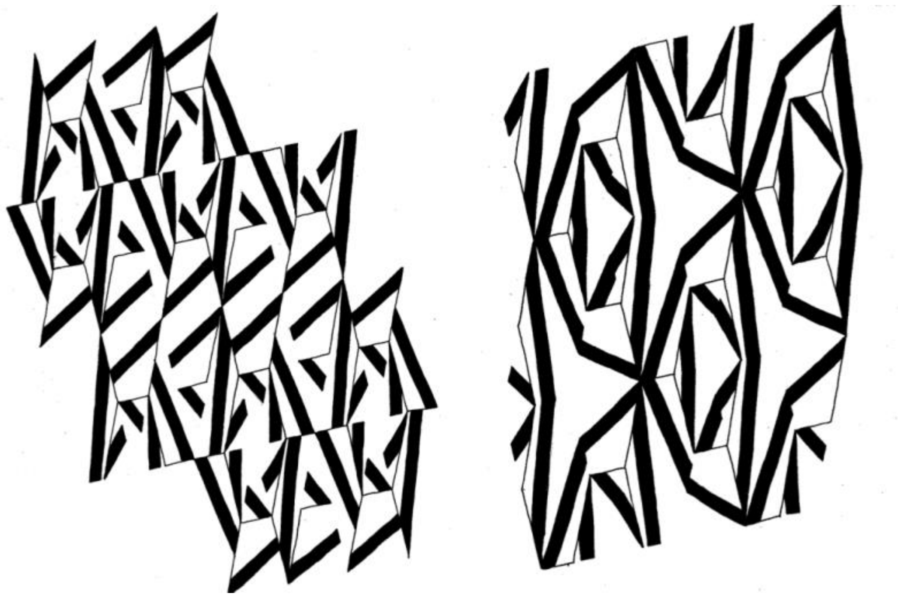

Figure 4. Exercise 1 from the student João Quadros (student nº2014396).

Materials. In the first moment, pencil and ruler for drawing the grid in A3 format paper were required; and after, two markers with different thickness for drawing in A3 tracing paper.

Measures and Procedure. Five measures were assessed in this exercise, in moment 1 and moment 2, which are:

(i) Demographic questionnaire: Demographic information (e.g., gender, age), students' expectations regarding the discipline, previous contact/interaction with VR were gathered.

(ii) Perceptions of Barriers to Personal Creativity Inventory: The students' perception about the barriers that influence creativity were assessed through a 5-points Likert type scale (1 "I completely disagree" to 5 "I completely agree"). Forty-four questions assessed the barriers to creativity in four factors: emotional (14 questions), personal motivation (12 questions), time, opportunities, and resources (10 questions), and social factors (8 question). This questionnaire was adapted and validated to Portuguese population (Morais et al., 2014).

(iii) Creativity level: Self-perceived level of creativity was assessed using a 5-points Likert type scale (1 "not creative" to 5 "extremely creative").

(iv) *Self-perception of Creativity and Motivation Inventory*: Students' perception of the barriers to creativity and motivation while performing the exercise were assessed through an adapted version of the Perceptions of Barriers to Personal Creativity Inventory and the Instructional Materials Motivation Survey (IMMS) (Keller, 2010) questionnaires. It includes

44 questions for perceived creativity barriers and 19 questions for motivation according to the motivational design categories from ARCS model (i.e., Attention, Relevance, Confidence and Satisfaction) as applied in the studies of Cruz (Cruz, 2010) and just used by Wei, Weng, Liu, and Wang (Wei et al., 2015). The questions for motivation were included in the following categories: attention (5 questions for attention, curiosity and interest); relevance (4 questions connected to the perceived relation between the challenge value and the value attributed to the learning); confidence (4 questions related to the believe in the ability to achieve the goals with success); and satisfaction (6 questions addressing the demonstration of satisfaction when expectations regarding the learning outcome are confirmed). The same Likert scale from the questionnaire Perceptions of Barriers to Personal Creativity Inventory was used.

(v) Performance: To avoid subjectivity in the judgment, students' performance was analysed by a jury of three professors, experts in Basic Design. The assessment took into account a set of pre-defined criteria that are usually applied in the assessment of this subject (i.e., technical, analytical, and aesthetic capacity). The initial assessment is individual, and later the 3 opinions were compared, with a subsequent moment of discussion to seek consensus and align the assessments.

The following questionnaires were given before the 1st exercise: Demographic Questionnaire (see Annex C, page 23); Perceptions of Barriers to Personal Creativity Inventory; and Creativity Level, both collected in the same questionnaire (see Annex D, page 27). After completing the exercise and grades were revealed, Self-Perception of Barriers to Personal Creativity and Motivation Inventory (see Annex E, page 35), and Performance, were collected.

Exercise 2

The objective of exercise 2 was the development of one 3D modular systems where the aesthetic quality and the diversity of visual effects should be valued, as well as the structural consistency of the physical models (see Figure 5). Using the same morphogenetic process and principles applied in the first exercise, three abstract structures (i.e., three elementary motifs) should be created using the same elementary part (i.e., an asymmetric 2D form previously chosen) placed in a sequential order. Each sequence brings out a visual effects/ volume, for which the previously learned concepts (i.e., sameness classes and symmetry operations) help to foresee the adequate geometrical-mathematical procedures (i.e., distances and angles).

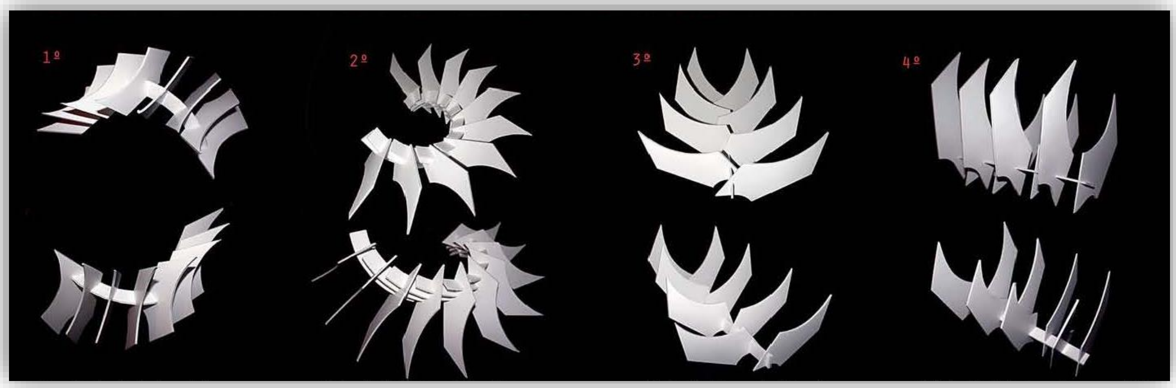

Figure 5. Exercise 2 from the student Andreia Araújo (student nº2014401).

Material. A VR-based tool was used to explain the exercise in the experimental group only. The control group received the instructions and explanations verbally and with the help of static images. All the students, regardless of the group they are assigned to, used K-line and craft knife for building the final 3D structures, which required, in previous moments, cardboard and drawing materials.

Measures and Procedure. The measures that were used in this exercise were Self-perception of Creativity and Motivation Inventory, Behaviour, Interaction, and Performance.

(vi) Behaviour and Interaction: The students' behavioural reactions to the structures presented in VR were video recorded for post-experiment analyses. The videos were watched individually and analysed according to a behavioural observation grid created for the study. The behaviour analysis grid made it possible to register the students' verbal reactions; gestural reactions; comments between students; and doubts about the exercise.

The briefing was presented and the VR-based tool was used to introduce the objectives, procedures, and materials along one class. Using a semi-immersive environment, the professor explained the exercise while the students interacted with the abstract structures from a 3D modular system, like the ones they are required to create. They could move the structures and walk around them as if they were physically present. They could understand the challenge at their own pace, according to their personal specific needs. The experience was intended to afford an easy shifting between different structures, multiple perspectives and points of view, and different materials, textures, and light effects. Two of those structures had animations for evidencing two important aspects of the exercise, i.e., the different possible forms of the connecting element and the fittings between all the parts. The conventional methodology used for introducing the second exercise to the control group includes verbal explanations and static pictures of some 3D abstract structures made by former 1st year students.

The procedure took place outside of the regular classroom, at the UNIDCOM/IADE VR Lab. Upon arrival, the students were given a brief explanation about the purpose of the study and asked to sign an informed consent form. Also, they were told that the entire procedure would be video recorded, for post-experiment analyses of behavioural reactions. After, they were seated in pairs in front of the wall screen and asked to wear the 3D shutter glasses. Once they declared they were ready, the professor gave them a general briefing about how to use the tool and explained the exercise (e.g., objectives, procedures, and materials). The students were stimulated to explore the VR-based tool while following the professor's introductory explanations (see Figure 7). At the end, the students were thanked, debriefed, and dismissed. The total duration of the experiment was around 10 minutes.

Self-Perception of Barriers to Personal Creativity and Motivation Inventory were collected with a questionnaire (see Annex F, page 45), as well as Performance, right after the exercise was complete and the grades were revealed. Also, Behaviour and Interaction were assessed through the video analysis.

VE. The VE crested for this exercise consisted in a closed room containing the target 3D structure positioned in the middle of the room. No sound was added to the VE. Six 3D structures were available to be positioned in the centre of the virtual room, as depicted in Figure 6, grouped according two modular systems, each one using a different elementary part. Both modular systems could be manipulated by changing seven variables: scale; rotation; translocation; observer position; animation; material; and light. In the control panel, shown in Figure 8, the details of each system were available, revealing the characteristics of the structures according to the theoretical concepts already introduced during the first exercise.

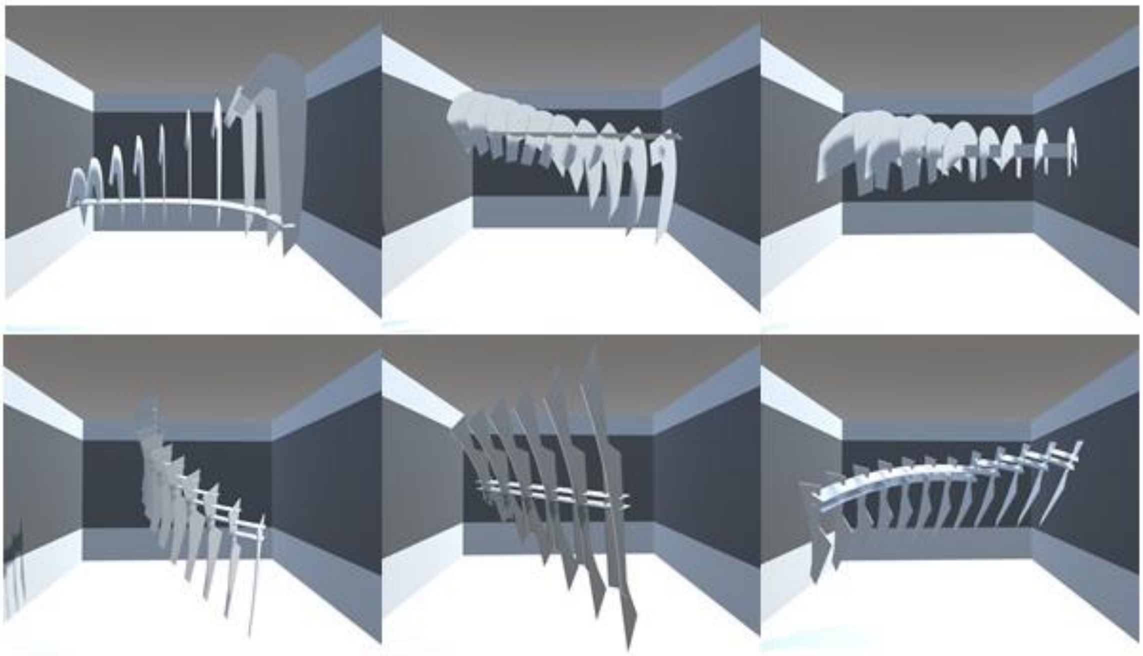

Figure 6. Screen shots of VE exhibiting 3D structures used during the procedure.

Experimental Settings. An Acer H6510BD 3D Video Projector was used to display the VEs and the structures, which were designed using 3D Max and then exported to Unity. nVIDIA (model 3DVision2) shutter glasses were used to see the VEs in stereoscopy and a video camera was used to record each session. Students were free to visually explore the VE by using a mouse. Pressing the left button of the mouse allowed moving around the structure. The exploration of the structures and the modifications of variables values such as the scale, translation, and rotation could be done using the mouse over a control panel on the VE (seen Figure 7).

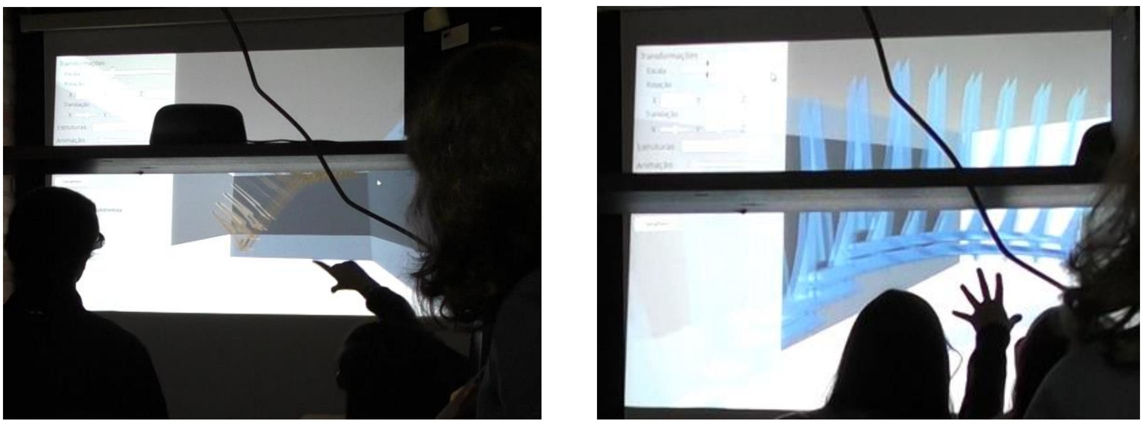

Figure 7. Students exploring the virtual environments (VEs).

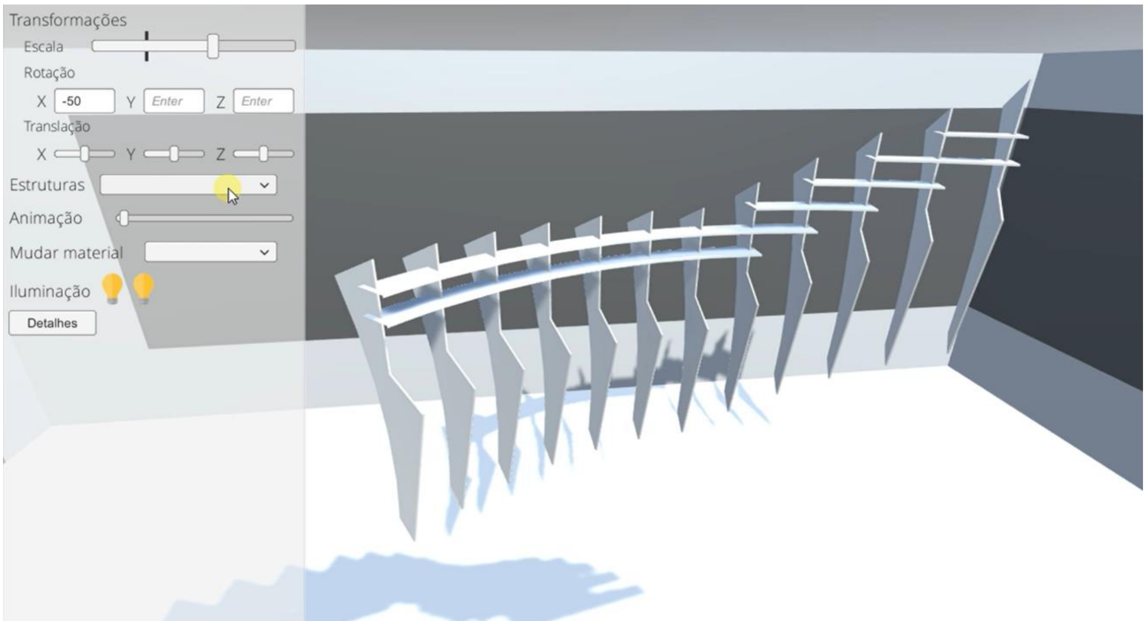

Figure 8. Control panel in the VE interface.

Exercise 3

In Exercise 3, a single structure was required. The aesthetic quality and structural consistency were the main objectives (see Figure 9). However, the creation process used, not a coupling of separated pieces, but a single plan that originated a volume with structural consistency by cutting, bending, folding, and fitting contiguous/adjacent figures.

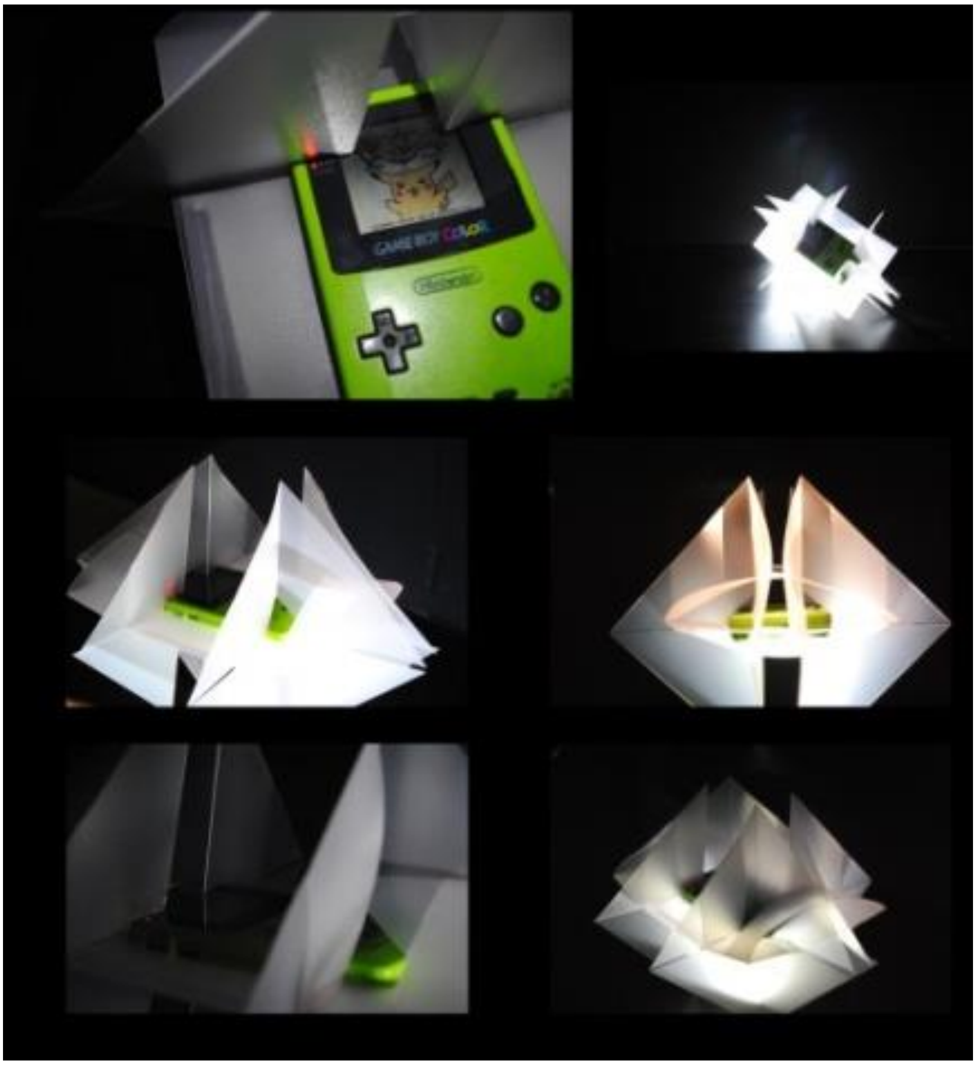

Figure 9. Exercise 3 from the student João Quadros (student nº2014396).

Materials: A second VR-based tool was used in the experimental group during the concept creation process. Polypropylene was the material selected to construct the 3D structure, to be created in the end of the exercise by both groups. However, other materials, such as paper/cardboard, adhesive tape, besides drawing and cutting materials were also required for exploring the concept.

Measures and Procedure. The measures that were used in this exercise were Self-perception of Creativity and Motivation Inventory, and Creativity Level. Behaviour, Interaction and Performance.

The briefing of the exercise was introduced and during the concept creation, a new VR-based tool was presented. Along one class, the students could explore individually the structures that had been created by then, in different and changeable contexts of use. In this sense, the 3D objects were tested in different situations, preserving the richness and complexity that usually occurs during real phenomenon interactions.

Both physical and virtual prototypes are used in design activities for the validation of the visual/haptic interaction approach (Bordegoni et al., 2013). Thus, exposure to different scenarios allow potential users to present their ideas and/or questions about the interaction with the concepts of a product, in existing or future contexts (Figure 13). These scenarios could be used in various stages of development of a product and could serve to understand their features, develop attributes of a product or assess users' behaviours in critical situations of interaction with a product or system (e.g., exposure to hazardous situations and/or costly events).

At the end of the exercise, after grades were revealed, Self-perception of Barriers to Personal Creativity and Motivation Inventory were collected, as well as Creativity Level, in the same questionnaire (see Annex G, page 55). Performance and Behaviour and Interaction were also gathered.

Experimental Settings. Same as Exercise 2.

VE. Students' own designs were shown in three different VEs using scenarios that vary from a public exterior/outdoor space (see Figure 10); a semi-public indoor space (see Figure 11); and a private indoor space (see Figure 12). Structures with different scales were used according to each space: living room (smallest scale); art gallery (medium scale); and garden (biggest scale).

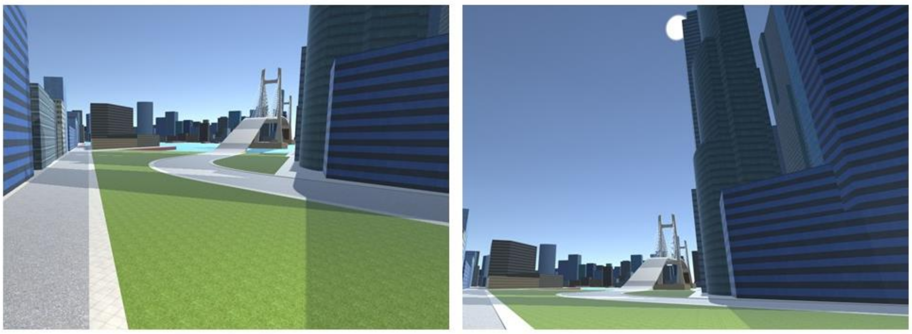

Figure 10. Public space in VEs.

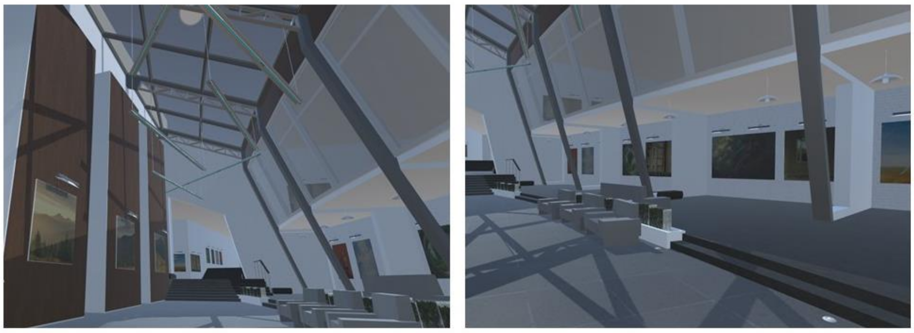

Figure 11. Semi-public space in VEs.

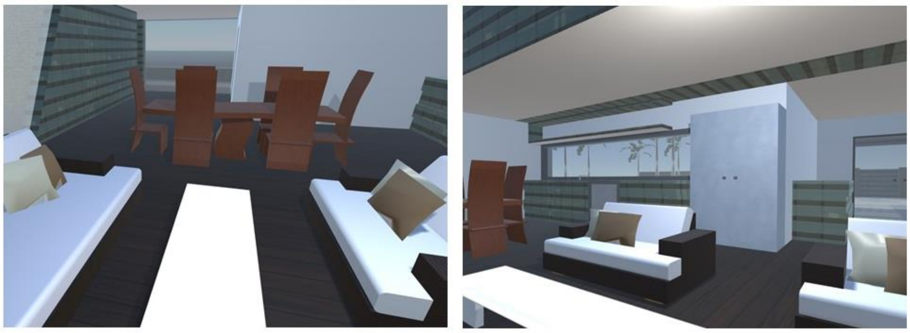

Figure 12. Private space in VEs.

The same interface was used, allowing the manipulation of the variables: scale; rotation; translocation; observer position; material; light; and two positions for the camera (i.e., interior and exterior cameras). In Figure 13 the students can be seen using the VR-based tool in exe. 3.

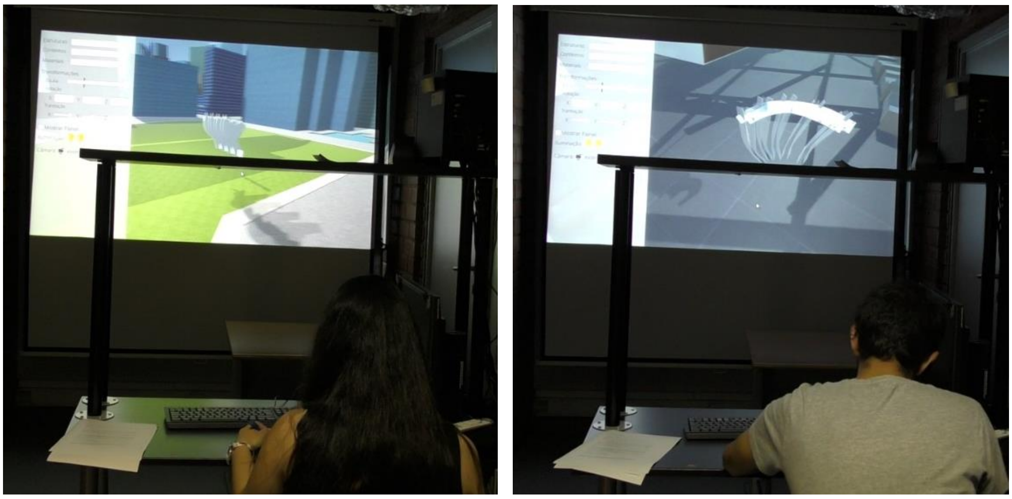

Figure 13. Students exploring the VE's in Exercise 3.

3.3.2. Analysing emotional responses

Following, the emotional response of the students to the experience of use was assessed by means of a video analysis. “PrEmo” tool, which stands for Product Emotion Measurement Instrument, developed by Pieter Desmet (2003), was used for this assessment. This tool was designed to help designers and researchers understand and measure the emotional responses that products and designs evoke in users. PrEmo categorizes emotional responses into 14 distinct emotions, which are further divided into 7 positive (desire, pleasant surprise, inspiration, amusement, admiration, satisfaction, fascination) and 7 negative emotions (indignation, contempt, disgust, unpleasant surprise, dissatisfaction, disappointment, and boredom). These categories allow for a more nuanced understanding of the emotional impact of products.

To carry out this analysis, a jury made up only by the teacher, in this phase of testing the tool (with the objective of using three researchers in the study phase) watched the videos and categorised the students’ response into one of the 14 emotions identified in PrEmo using the following observations taken from the videos:

- Facial Expression: this is one of the most common methods to detect emotions. The jury tried to recognize facial cues such as smiles, frowns, eyebrow movements, and eye expressions. However, facial expressions were not available during all the experiment, as students were faced back to the camera. Thus, we analysed only expression recorded before and after the experiment.
- Voice and Speech: Emotional responses are often reflected in the tone, pitch, and speed of speech. Whenever the students verbalised a comment, the jury tried to identify those variables.
- Behavioural Analysis: the jury observed behavioural cues, such as body language, gestures, and posture.
- Content Analysis: the jury took notes on the words present on the users’ verbalizations and look for meaning and emotional tone of the text. This can provide additional context for understanding the emotional response to the video.

Other variables, such as the doubts presented to the teacher; time of interaction; and apparent ease of use, were also considered.

The observations were recorded in a matrix and, classified each participant's emotional expression into one of the 14 PrEmo emotions. In the following study phase, the judges' classifications would be compared, and a consensus would be sought.

3.4. Results and discussion.

Data were analysed with SPSS v.21 and an alpha level of .05 was used for all inferential analyses. Whenever the normality of the distribution was guaranteed ($p > .05$), parametric tests were used.

3.4.1. Creativity level

Creativity level between subjects

To assess the existence of differences in perceived creativity between the two groups, two Mann-Whitney tests were performed for each time point. Mann-Whitney test revealed that there are no statistically significant differences between the groups in moment 1 ($Mdn_{\text{expgroup}} = 9.5$; $Mdn_{\text{contgroup}} = 11.5$), $U = 40.00$, $p = .34$, and moment 2 ($Mdn_{\text{expgroup}} = 10.5$; $Mdn_{\text{contgroup}} = 10.5$), $U = 50.00$, $p = 1$. (see Tables 1 and 2 in the Annex H, page 47).

Creativity level within subjects

To assess the existence of a variation in students' perceived creativity between the two moments, a Wilcoxon Signed-Ranks test was applied, which indicated that perceived creativity has no significant variation between moment 1 and moment 2, neither in experimental group, $Z = -1.00$, $p = .32$, nor in the control group, $Z = .000$, $p = 1$ (see Figure 14; and Table 3 in the Annex H, page 47).

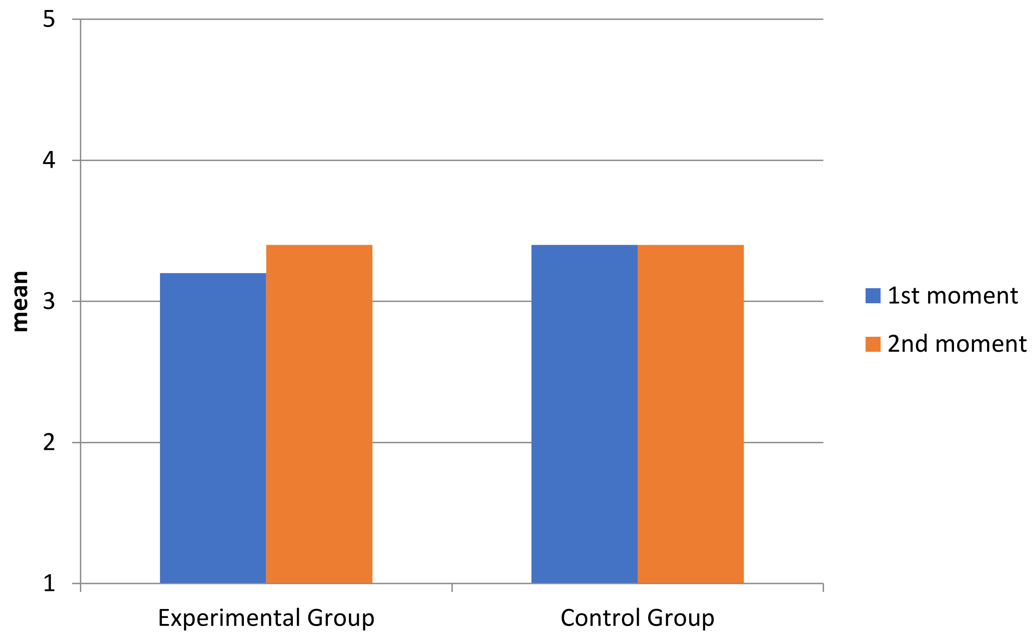

Figure 14. Perceived Level of Creativity within subjects.

3.4.2. Barriers to Personal Creativity

A one-way ANOVA was performed to compare the effect of the VR tool on Barriers to Personal Creativity. A one-way ANOVA revealed that there was not a statistically significant difference in Perceived Personal Creativity between the two groups (see Table 4 in the Annex H, page 48) in any moment it was assessed.

3.4.3. Motivation

Motivation between subjects

A one-way ANOVA was performed to compare the effect of the VR tool on Motivation. A one-way ANOVA revealed that there was a statistically significant difference in Motivation between the two groups (see Table 5 in the Annex H, page 48) at moment1 in factor A (Attention), F (1,18) = 7.92, p = .011, at the moment 2, in factor S (Satisfaction), F (1,18) = 165.26, p < .001, and at the moment 3, in factor S (Satisfaction), F (1,18) = 5.81, p = .027.

Two ANOVA for repeated measures 4 (Motivation: A – Attention; S – Satisfaction; R – Relevance; C - Confidence) x 3 moments (After exercises 1, 2 and 3) were performed for each group.

For the Experimental Group, the ANOVA revealed no statistically significant differences between the level of motivation, in any factor, in the 3 moments: main effect of motivation, F (3,27) = 2.73, p = .06; main effect of evaluation moment, F (2, 18) = 2.15, p = .15; interaction motivation X moment of evaluation, F (6,54) = 1.24, p = .29. (See Table 6 in the Annex H, page 49-50).

For the Control Group, the ANOVA revealed a significative main effect of motivation, F (3,27) = 17.73, p < .001, and a significative interaction motivation x moment of evaluation F (6,54) = 40.04, p < .001. The main effect of the evaluation moment was not significative, F (2,18) = 7.18, p = .005. (See Table 7 in the Annex H, page 50).

Pairwise comparisons revealed that S (Satisfaction) is minor than A (Attention) (p = .005), R (Relevance) (p = .003), e C (Confidence) (p < .001) (See Table 8 in the Annex H, page 51).

3.4.4. Performance

A one-way ANOVA revealed no statistically significant differences between the grades of the experimental and control groups in exercise 1 ($M_{ExpGroup}$ = 16; SD = 2.00; $M_{ContGroup}$ = 15; SD = 2.58), F (1,18) = .94, p = .35; in exercise 2 ($M_{ExpGroup}$ = 16.10; SD = 2.64; $M_{ContGroup}$ = 15.30; SD = 3.97), F (1,18) = .28, p = .60; in exercise 3 ($M_{ExpGroup}$ = 15; SD = 2.30; $M_{ContGroup}$ = 13.90; SD = 3.45), F (1,18) = .70, p = .41; and in final grade ($M_{ExpGroup}$ = 15.90; SD = 2.33; $M_{ContGroup}$ = 14.20; SD = 3.12), F (1,18) = 1.91, p = .18. (See Table 9 in the Annex H, page 51).

3.4.5. Video recorded analysis.

The immediate contact with the tool triggered some reactions in some students, such as arms movements trying to touch the structures; vocalizations (e.g., "*Uuuu!", and "Uau!"*); and laughs. During the session, comments of students, such as: *"funny"; "But this is very funny"; and "what a twist"*[7] were registered. Another student expressed: *"Top, look there!"*[8] when referring to the animation that reveals the way of assembling the pieces. Besides the comments, his body movement during the interaction revealed enthusiasm (e.g., moving his head

[7] Free translation from the original - "engraçado"; "mas isto é muito engraçado"; "que giro"; um outro estudante referiu: "esse tá bué fixe"; "tá fixe este efeito."

[8] Free translation from the original - *"top, olha lá!"*

frequently following the structures; imitating the rotation at the animation C moving the arms and hands, and pointing the commands to the colleague, moving arms and hands toward the screen. Also, in the free exploration phase, the same pair of students commented the structures resembling them with specific objects (e.g., boat casquet, tree). Another pair of students laugh out loud when a specific animation was activated. The same reaction was verified by others when exploring the successive rotations of the structure and the spinning effect. Verbalizations at the end of the session were noticed, when a student mentioned to the colleague, before leaving the room: *"Very good!"*[9] Comments between students were frequent, related to the exposed new concepts: *"Homeometry was the one we were seeing - yes"* [10] or requests to change the position of the structure. Students change information about the proper commands to obtain a position. Specifically, one explains where the command is to rotate the structure, pointing to the screen and, in another group, another asks the partner to activate the homeometry. Also, questions and doubts were posed to the teacher related to the presented exercise: *"But are we really going to build it?" (nº 3)*; *"Which are the animated ones, teacher? (nº 4)*; *"This connection is not straight? ... that is, just do not just join it ... I realized, okay, I was trying to perceive" (nº 10); "Oh, they have to fit all!"; "Does it have to be all K-line work?; Does it have to be at least 10 pieces?; Is that already counting on the connecting pieces?; We can make our own piece like this one, right?" (nº 7)*[11]

In pairs, students share ideas and overcome some doubts (nº 4). In a specific group where only one of them manipulated the structures (nº 4), while the other preferred to observe the colleague's moves (nº 5), was verified that the one that actively used the tool understood the procedure and could explain it to the colleague.

As to the emotions observed, from total of 10 students, all of them showed some level of satisfaction during the session; 3 revealed to have been pleasantly surprised in some moments; 3 showed to be amused; and other 3 revealed fascination, during the interaction with the VR-based tool.

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[9] Free translation from the original - "muito bom!"

[10] Free translation from the original - "homeometria era aquela onde estavamos há bocado – sim"

[11] Free translation from the original - "Mas vamos mesmo construir?" (Nº 3); "Quais são as que animam, professora? (Nº 4); "esta ligação não é reta?...ou seja, basta não ser só o juntar…já percebi, ok, estava a tentar perceber" (nº 10); "Ah, têm que encaixar todas!"; "Tem que ser o trabalho todo em K-line?";tem que ser no mínimo 10 peças? Isso já a contar com as peças de ligação? Como esta peça foi feita também podemos fazer, não é? (nº 7).

3.4.6. The flexible script

Although the teacher used a script to guide the 10 minutes presentation scheduled for each pair of students, few more minutes were required for free exploration. She felt important that all the students understood the exercise, at their own pace. In that sense, the script was very useful, but revealed to be just a mere orientation. The teacher answered students’ questions whenever asked and guaranteed the engagement during that time.

All students revealed to have understood the future exercise, although each group achieved that comprehension in a different manner. While some of them showed to be more autonomous and were very much at easy during the interaction, others were less comfortable, but still, did everything without problems. All students showed some level of satisfaction during the session. We could say that from the group of ten, three revealed to have been pleasantly surprised in some moments, and the same number showed quite amused. Fascination was also revealed by three of them.

The second VR-based tool was used under different conditions, as already mentioned. From the analysed sample, only four of the students used a structure modelled by themselves, while the others used a specific one created for the purpose of this experience. The digital modelling of the structures was optional since it was not required in the curricular unit program. In this sense, most of the students haven't created their own structure, despite the given tutorials. During both sessions, the teacher was at the classroom and didn’t orient the experimental activities. Specially in the second day, students were completely involved in the curricular task at hand related with the final exercise and, although the teacher highlighted the importance of the activity, they rushed during the virtual interaction and, consequently, under explored the tool. Sometimes the researcher was giving suggestions for exploring missing commands.

Both groups (i.e., one per session) had different conditions while conducting the exercise. While the first group was introduced to the interface, the second one was not. In this case, the researcher suggested the exploration of some commands according to the student’s reactions.

All students explored every different scenario. They showed neutral face expressions and sometimes, a smiling face, revealing no unpleasant emotions. Instead, some rush to complete the task was noticed, especially when looking for the time spent on the second day, that was considerably lower (i.e., average of 8.17, in the first day, and 3.5 minutes, in the second day). In the first session students used the time to take notes about their impressions. They carefully explored different possibilities and showed some interest and engagement in the activity, while the other group evidenced lack of interest in the activity.

There is one student that reacted vocally, when activated the panel: *“ah!”*. Another said, in the interior camera: *"Oh how funny"* and, *"oh how strange"*[12]*,* revealing a pleasant surprise. To some students, the abstract structures presented many differences from the ones they were working manually at that moment. From a premature phase, during the third exercise, the students changed the structures according to their preferences and most of them did not resemble the initial ones.

3.5. Chapter Summary

The objective of this study was to present a VR-based methodology to contribute to innovate Basic Design education. Two VR tools were created and tested for this purpose. The study was conducted in *Laboratório de Design 3D* course at IADE, a Portuguese Design University, in 2016 Spring semester. We expected the VR-based tools to help overcoming some difficulties noticed by the first-year design students and impact the teaching-learning process.
The VR technology impact on the BD course was assessed by collecting the students’ perceptions of barriers to personal creativity, creativity level, self-perception of creativity and motivation as well as their performance. However, the results fail to show significative differences on the measures gathered by the experimental and control groups, suggesting new directions to the study. Although the results don’t clearly show a positive impact of VR, we have taken into account some interesting findings, such as the positive overall experience, particularly evidenced in the emotional responses of the students during the interaction with VR.

We derived the following reflections about the constraints, and considered some possible limitations of the study, as well as possible contributions for next studies.

- **Technical occurrences:** As a typical basic design professor doesn’t normally have competencies on computer graphics or computer sciences, it should be noticed the need of constant support from a computer engineer during all the phases of the VR-based tool conception, process and data collection. The number and the timing of

[12] Free translation from the original - “ai que engraçado” e também: “ai que estranho.”

the technological occurrences are difficult to foreseen, which can jeopardize a whole class day for the students, requiring a careful planning.

- **Limited natural body movements:** Despite the “wow” moment, video recorded during students’ first interactions with the VR tool, a mouse and a keyboard restricted students’ natural body movement. This fact can be limiting their performance results and negatively affecting other measures, including the sense of presence and engagement, specially, when considering the importance of the proprioception in the learning process, whether for developing Lab D3D required expressive capacities (Neves & Duarte, 2015b) or for eventually more advanced features of Basic Design synaesthesia (Guerini, 2001).
- **Limited time:** The short time for the interaction with the VE was also due to the restricted number of 3D glasses and other equipment available, thereby impeding multi-users sharing activities and a repeated access to the tool, if required. In this case, fully immersive solutions with HDM (Head Mounted Displays) and/or Internet-based, soon available off-the-shelf, can make a difference in the potentialities of these tools. Certainly, it will affect the quality of the interactions in VR-based learning experiences, possibly also connected with gamification strategies, mobile and/or e-learning principles.
- **Proficiency with technology:** Previous training on 3D computer graphics and digital modelling software may be needed to establish the basic requirements for the first-year design student’s participation. A poor proficiency with such tools can narrow the potential of the second VR-based tool during Exercise 3, which intends to be used for anticipating the visual effects of each student concept creation, in different contexts and scenarios. Thus, enabling digital 3D skills to the newly arrived design students is desirable.

The experimental study described in this study allowed testing the developed procedures and tools in pedagogical context. It also allowed the acknowledgment of the complexity of such task and provided possible directions for future work. Some major difficulties were noticed on the integration of the research activities in the programmatic activities:

- **Planning:** because many students were late with the assignments, their availability to participate in the experiment was diminished due to the deadline approach and, therefore, only few answered the last questionnaire after completing the last exercise of the semester. They were asked to answer the questionnaire in the following semester, i.e., 2016-17, which affected the results. An adequate timing is important, e.g., contemplative, instead of high time pressure moments.

- **Low proficiency with 3D modelling software:** despite the given tutorials, the students revealed important difficulties to model digitally their structures. To overcome this difficulty, we provided them a pre-modelled structure and they were discharged from the 3D modelling activity. In future studies, students should be previously trained on using 3D software.
- **Limitations of the VR system:** the used VR system presented limited interaction abilities; e.g., the device used for interacting with the VE was a keyboard and a mouse. It was evident that the devices restricted students' natural movements, affecting their performance, motivation and creativity, including the sense of presence and engagement, specially, when considering the importance of the proprioception in the learning process. In future studies, other devices, e.g., Leap Motion or VR gloves, should be tested.
- **Technical assistance:** The system required constant technical support, demanding both competencies on computer graphics and computer sciences. Because the amount and timing of the technological occurrences are difficult to foreseen, which can jeopardize a whole class day for the students, a careful planning is required to allow a regular assistance by the VR engineer/technician.
- **Methodological limitations:** a double-blind evaluation of the results gathered from the students was not possible because only one class/professor was involved in the experimental study. Thus, the regular score given by the class professor, that proceeded as usual, was used to assess the students' performance on Lab D3D. Other measures of performance should be used in future studies.
- **Duration of the VR experience:** Because of the nature of the planned exercises and the features of the VR system, the experience with the VR was relatively short (i.e., a few ten minutes for a pair of students, in the VR-based tool 1; and ten minutes for each one during the use of the VR-based tool 2). Thus, an effect of the reduced time available during the interaction on the results gathered is very likely.

Considering the difficulties listed above, as well as the nature and characteristics of the Lab 3D course, a decision was made to not continue with the study in this course, making it necessary the selection of another case study for continuing the research.

Finally, the presented ideas lead to our last and provoking thought, which is the possibility of transferring the entire conception process used at Lab D3D to the digital medium. Would it be possible, with the right support of VR technology, to eliminate the manual component of the Basic Design discipline? Inevitably, it requires for uncovering its advantages and disadvantages, for which the presented methodological approach can be a starting point.

3.6. References

Abdelaziz, M., Riad, A., & Senousy, M. B. (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), 320–328.

Anceschi, G. (2010). Design di base: Fondamenta del design. *Il Verri 'Newbasic'*, *43*. http://www.ilverri.it/index.php/la-rivista-del-verri/edizione-dal-1996/newbasic-detail

Bamford, A. (2011). *LiFE: Learning in Future Education Evaluation of innovation in learning using emerging technologies* [Project].

Bonsiepe, G. (2012). *Design como Prática de Projeto*. Edgard Blucher.

Bordegoni, M., Ferrise, F., & Cugini, U. (2013). Development of Virtual Prototypes Based on Visuo/Tactile Interaction for the Preliminary Evaluation of Consumer Products Usage. In A. Chakrabarti (Ed.), *CIRP Design 2012* (pp. 149–158). Springer London. https://doi.org/10.1007/978-1-4471-4507-3_15

Bossard, C., Kermarrec, G., Buche, C., & Tisseau, J. (2008). Transfer of learning in virtual environments: A new challenge? *Virtual Reality*, *12*(3), 151–161. https://doi.org/10.1007/s10055-008-0093-y

Boucharenc, C. G. (2006). Research on Basic Design Education: An International Survey. *International Journal of Technology and Design Education*, *16*(1), 1–30. https://doi.org/10.1007/s10798-005-2110-8

Burdea, G. C., & Coiffet, P. (2003). *Virtual Reality Technology* (2 edition). Wiley-IEEE Press.

Carvalho, A. A. A. (2011). *A teoria da flexibilidade cognitiva e o modelo múltiplas perspectivas*. http://repositorium.sdum.uminho.pt/handle/1822/15921

Cetinkaya, C. (2014). Basic Design Education Parameters in Turkey. In *Humanitas International Journal of Social Sciences* (pp. 31–46). Central and Eastern European Online Library.

Creswell, J. W. (2013). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, 4th Edition* (4th edition). SAGE Publications, Inc.

Cruz, S. (2010). *Proposta de um modelo de integração das tecnologias de informação e comunicação nas práticas lectivas: O aluno de consumidor crítico a produtor de informação online*. http://repositorium.sdum.uminho.pt/handle/1822/10678

Desmet, P. (2003). Measuring Emotion: Development and Application of an Instrument to Measure Emotional Responses to Products. In M. A. Blythe, K. Overbeeke, A. F. Monk, & P. C. Wright (Eds.), *Funology* (pp. 111–123). Springer Netherlands. https://doi.org/10.1007/1-4020-2967-5_12

Droste, M. (1992). *Bauhaus 1919-1933*. Taschen.

Fernandes, R. (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.* (http://eprints.ucm.es/12198/1/T32379.pdf). Universidade Complutense de Madrid.

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

Gu, N., Gul, L. F., & Williams, A. (2010). Methods for evaluating 3D Virtual Worlds in Design Education. *International Design Conference - Design 2010*, 1259–1266.

Guerini, S. (2001). *Il Corpo Risponde. Le sinestesie nella didattica multimediale* [Licenciatura, Politecnico di Milano]. https://issuu.com/silviaguerini/docs/il_corpo_risponde_silvia_guerini_ca

Jones, D. (2013). An Alternative (to) Reality. In M. Childs & A. Peachey (Eds.), *Understanding Learning in Virtual Worlds* (pp. 1–20). Springer.

Keller, J. M. (2010). *Motivational Design for Learning and Performance*. Springer US. http://link.springer.com/10.1007/978-1-4419-1250-3

Lanyi, C. (Ed.). (2012). *Applications of Virtual Reality*. InTech.

Lee, E. A. L. (2011). *An investigation into the effectiveness of virtual reality-based learning* [Phd, Murdoch University]. http://researchrepository.murdoch.edu.au/4070/

Merchant, Z., Goetz, E. T., Cifuentes, L., Keeney-Kennicutt, W., & Davis, T. J. (2014). Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis. *Computers & Education*, *70*, 29–40. https://doi.org/10.1016/j.compedu.2013.07.033

Milgram, P., Takemura, H., Utsumi, A., & Kishino, F. (1995). Augmented Reality: A class of displays on the reality-virtuality continuum. *Proc. SPIE 2351, Telemanipulator and Telepresence Technologies*. Telemanipulator and Telepresence Technologies. https://doi.org/10.1117/12.197321

Morais, M. de F., Almeida, L. S., Azevedo, I., Alencar, E., & Fleith, D. (2014). Inventory of barriers to personal creativity: A validation study involving university students. *The European Procedia Social and Behavioural Sciences Ep-SBS*, 135–146. https://doi.org/10.15405/epsbs.2014.05.16

Neves, A., & Duarte, E. (2015). Using Virtual Environments in Basic Design Education. In E. Duarte, C. Duarte, & F. Carvalho Rodrigues (Eds.), *Senses & Sensibility'15 Proceedings* (pp. 273–280). IADE - Creative University / Edições IADE.

Rebelo, F., Duarte, E., Noriega, P., & Soares, M. M. (2011). Virtual Reality in Consumer Product Design: Methods and Applications. In Waldemar Karwowski, Marcelo M. Soares, & Neville A. Stanton (Eds.), *Human Factors and Ergonomics in Consumer Product Design: Methods and Techniques* (pp. 381–402). CRC Press.

Schank, R. C. (2011). *Teaching Minds: How Cognitive Science Can Save Our Schools*. Teachers College Press.

Sharples, S., Cobb, S., Moody, A., & Wilson, J. R. (2008). Virtual reality induced symptoms and effects (VRISE): Comparison of head mounted display (HMD), desktop and projection display systems. *Displays*, *29*(2), 58–69. https://doi.org/10.1016/j.displa.2007.09.005

Spiro, R. J., Collins, B. P., & Ramchandran, A. R. (2007). Modes of Openness and Flexibility in Cognitive Flexibility Hypertext Learning Environments. In B. H. Khan (Ed.), *Flexible Learning in an Information Society*. Idea Group Inc (IGI).

Wei, X., Weng, D., Liu, Y., & Wang, Y. (2015). Teaching based on augmented reality for a technical creative design course. *Computers & Education*, *81*, 221–234. https://doi.org/10.1016/j.compedu.2014.10.017

Chapter IV

(...) in the Fifth Empire there will be the reunion of the two long-separated, but long-coming forces: the left side of wisdom - that is, science, reasoning, intellectual speculation; and its right side - that is, occult knowledge, intuition, mystical speculation and kabbalistic.[13]

Fernando Pessoa

4. Portuguese Basic Design in Learning Outcomes

4.1. Abstract

Learning Outcomes (LOs) are increasingly emphasized in Higher Education (HE) systems all over the world as supporting globalization when considered at the macro scale of influence. Towards the setting of a solid background for innovative BD teaching-learning approaches that include, but are not limited to, digital-based tools, this study focuses on the LOs micro scale of influence. This tripartite study addresses the gap of knowledge about the presence of BD courses in the context of Portuguese HE system and what are the competences they require. It aims specifically the identification of: i) existent courses; ii) the main components (i.e., levels of understanding and content topics) of the LOs present in the courses, as defined in the constructive alignment theory; iii) and the prominent combinations of levels of understanding and content topics.

For addressing the first objective, we created a matrix with which we analysed the current panorama of BD in higher education in Portugal. The creation of the matrix required a systematic analysis of the main literature related to BD, specifically, the documents produced by the design teaching pioneers that largely influenced the origin of Portuguese design education. The study plans, previously collected, were analysed according to the conceptualized matrix, which allowed the identification of the BD-derived courses.

[13] Free translation from the original: (…) no Quinto Império haverá a reunião das duas forças separadas há muito, mas de há muito aproximando-se: o lado esquerdo da sabedoria – ou seja, a ciência, o raciocínio, a especulação intelectual; e o seu lado direito – ou seja o conhecimento oculto, a intuição, a especulação mística e cabalística.

For setting the next two objectives we applied a qualitative approach. The MaxQDA software was used for the content analysis. The results of this study enabled us to gather: i) a list of the Portuguese courses that lecture BD, organized by the type of educational system (i.e., university institutions vs. polytechnics), per economic sector (i.e., public vs. private institution); and type of study program; ii) a detailed conceptual matrix of the levels of understanding and content topics found in the LOs; iii) and the prominent combinations of those components, highlighted by frequency and importance, as performed by the students in Portuguese BD courses.

4.2. Chapter Introduction

This part of the research follows the verified need to redirect the study design. Although the general objectives were maintained in the new condition, which was the creation of a VR-based tool for learning a set of BD skills, the objective of identifying the LOs that the VR tool should make it possible to achieve was included. In this sense, the present study aims specifically to identify: i) the existence of Portuguese BD courses; ii) the LOs present in the courses, in its main components (i.e., levels of understanding and content topics) as defined in the constructive alignment theory; iii) and the prominent combinations of levels of understanding and content topics used in the Portuguese BD courses, detailed in subcategories. The first objective was addressed independently of the two last objectives. These are linked and presented together, as the prominent combinations of levels of understanding and content topics complements and extends the previous identification of such elements in the LOs. Besides, both apply the same methodology.

4.2.1. Basic Design

The original 1919 Basic Design course, the preliminary, later called basic course, was considered as one of the main pillars of the Bauhaus Design School (1919-1933) (Bonsiepe, 2012) and, in the opinion of Cross (1983), Bauhaus most important educational innovation. According to its creator, Johannes Itten (1888-1967), the course aimed at students to: access inner experiences, perceptions and creative forces that would release them from preconceptions by enabling confidence in free expression and creation; discover unique personal characteristics by experimenting with different materials/mediums, thereby easing their choice of career; and finally, be aware of the principles of form and colour in composition for applying them in articulation both in objective and subjective modes (Itten, 1975). After one century, BD is internationally consolidated as an introductory course to the design principles, targeting first-year undergraduates in design. Nationally, recent studies identified its permanence in the Portuguese HE system (Neves, Dias & Duarte, 2018) and revealed the presence and evolution of BD over fifty years of the design study programs at IADE design school (Neves, Duarte & Dias, 2018).

4.2.2. Learning Outcomes

Bologna Declaration impact on the HE system established learning outcomes as a key instrument (OECD, 2012), becoming a familiar and relevant expression among all the actors. Next to and aligned with assessment methodologies and curricula design, LOs constitute the "Framework for Qualification of European Higher Education." LOs, also identified as: academic goals; expected results; and learning objectives, describe the abilities that should be performed by the learners after a learning experience. A set of knowledge, skills, and competences are embodied in the LOs, which also include values, beliefs, and attitudes to be achieved by students (Dias, 2017, p. 1).

4.2.3. Constructive Alignment theory

The constructive alignment theory was created by Biggs (Biggs & Tang, 2007) and is based on the constructivist theory of learning. It is known for addressing the enhancement of teaching and learning that focus on outcomes, often referenced as outcomes-based teaching and learning (OBTL). The design of learning activities, in constructive alignment, ensures the presence of the intended verb in the outcome statement, in the teaching/learning activity and in the assessment task. They are the key to the whole system. The desired outcomes of teaching specify the performance that students should achieve in terms of the level of understanding a certain content topic. SOLO taxonomy uses a list of appropriate verbs in two main categories: quantitative and qualitative, corresponding respectively to the low level and high level. A pre-structural level precedes all the other levels, and stands for non-existing competences. It is mostly used in the evaluation phase of the learning process. The low-level outcomes involve simple and quantifiable verbs. They are considered unistructural level (e.g., identify; memorize; and doing simple procedures) and multi-structural level (e.g., enumerate, describe, list). As for the quality phase, the high-level outcomes are subdivided in relational level (e.g., compare/contrast; explain causes; analyze; apply) and extended abstract level (e.g., crating; theorizing; reflecting; grounding). There are appropriate levels for each level taught and, in the case of HE system, intended outcomes would be predominantly high level (Biggs & Tang, 2007).

4.3. Methodology

The first step intended to conceptually map BD in the present scenario of HE, in Portugal (Neves, Dias, et al., 2018) [subsequently reviewed by Neves et. al (2019)]. An aggregator set of characteristics that unveiled the presence of teaching-learning paths appealing to this nature was proposed taking in consideration the main literature related to the BD. Thus, we started by analysing the main literature related to BD, specifically the documents produced by the design teaching pioneers that largely influenced the birth of Portuguese design education.

At the same time, we started collecting the curricular plans of the design courses. Firstly we collected them from the institutional websites. Whenever the documents were not available online, we requested the documents by emailing the institution, and in some cases, a direct request to the pedagogic department was sent.

The gathered study plans of the Portuguese HE Design courses were analysed and, according to the previously established matrix. We selected the courses that were considered configurators of the BD principles. The selection was made according to the presence of some of the following settings, in several degrees of combination:

- the workload/ ECTS;
- the experimental methodologies, with a strong practical component intending the promotion of creativity and requiring the valorisation of free exploration, using different materials and techniques;
- the programmatic contents, by including the principles of 2D and 3D design, such as symmetry, formal coherence, modularity and standardization, and others attributed to the visual arts, such as harmony, balance, including the Gestalt laws;
- the learning objectives, such as the design of objects according to more aesthetic than technical parameters, more personal than specific from the discipline.

Afterwards, the Portuguese Design courses that lecture BD were presented by type of educational system (university institutions vs. polytechnics), per economic sector (public vs. private institution); and per type of study program.

The analysis allowed the identification of the BD-derived courses, in which the concepts were found in several degrees of combination. Complementarily, each study plan was analysed more subjectively, in the sense that a global understanding was, in some cases, necessary to decide whether the Curricular Unit was to be considered as following or not the BD tradition. The diagram of the study model is presented bellow, in Figure 15.

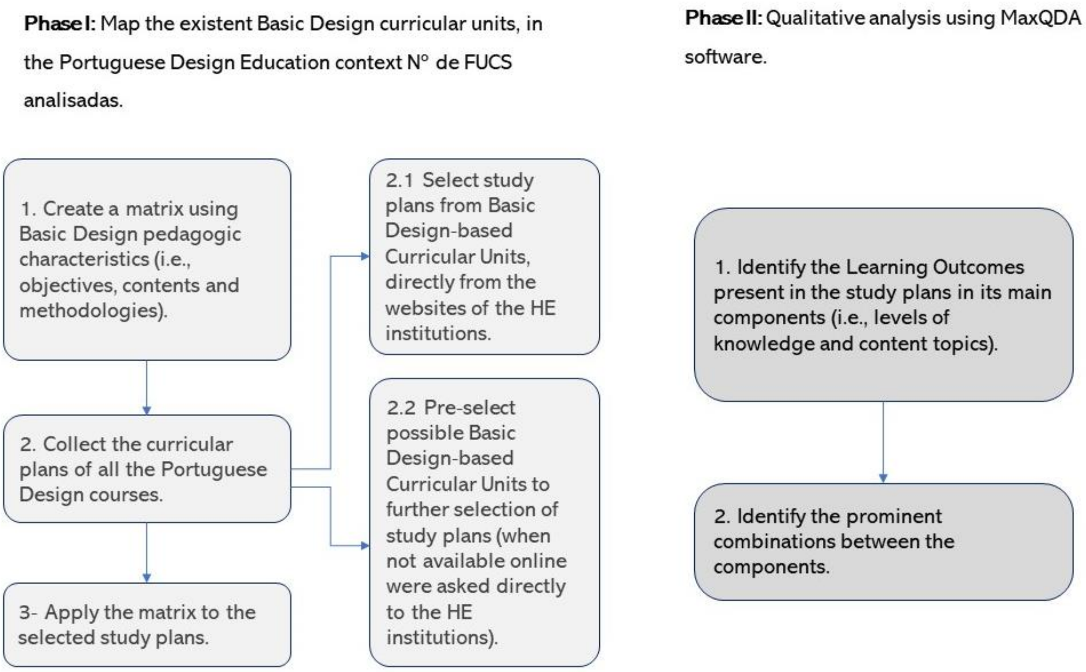


Figure 15. Diagram of the study model.

4.3.1. Tools for Basic Design content analysis

Data codification

Due to the different characteristics of the design courses (e.g., general and specialized according four different areas) the codification of the study plans followed the *Classificação Portuguesa de Profissões (CNP)*, a Portuguese professional classification (Agapito et al., 2015):

- Industrial Design and Equipment Design (DPIE);
- Textile Design and Fashion Design (DTM);

- Interior Design, Space Design and Environment Design (DIEA); and
- Graphic Design, Communication Design and Multimedia Design (DGCM).[14]

We added Generic Design (GD) to the list, since High Education design courses also offer more generalists approaches that address all areas, opening to future specialisation, (e.g., by taking a master-degree course).

Respectively, the identification of each study plan includes the abbreviation of the specialization area numbered sequentially according to our list, followed by its name (e.g., DPIE_8-Introducão ao Design).

Conceptual Matrix

From the main literature produced by the pioneers of design education and, particularly, BD education, that largely influenced the birth of Portuguese design education, we identified the following parameters:

- Basic Design concept;
- Objectives/learning outcomes;
- Teaching and learning methodologies; and
- programmatic content.

The main references include the ones used by Daciano da Costa for the creation of an informal Basic Design course at his workshop, between 1962 and 1964 (Costa, 2001); IADE's references for the Italian influence on the seventies and eighties; and the significant design teaching models considered for the implementation of design courses in the public HE. The references considered are Johannes Itten (1975); Gui Bonsiepe (1992); Basel School of Design, Switzerland (V. Almeida, 2009); László Moholy-Nagy (1947b); Josef Albers; Bruno Munari (1979, 1998) and Marcolli (1971, 1978) (see Table 3).

[14] Free translation from the Portuguese: "*Design de Produto Industrial ou de Equipamento (DPIE)*; *Design de Têxteis e Moda (DTM)*; *Design de Interiores, Espaços ou de Ambientes (DIEA)*; and *Design Gráfico de Comunicação e Multimédia (DGCM)"*

Table 3. Conceptual matrix.

Objectives/learning outcomes	Pedagogical methodologies	Programmatic content
self-confidence	experience with the senses;	theory and practice of polar
discover the self	objective these at an	contrasts
discover self-talent	Intellectual level; and realize	laws of form (expressive,
original/genuine work	these through synthetic	subjective, complex)
develop individual	means	texture
discover potential	theory and practice of polar	rhythm
make career choices	contrasts	chiaroscuro
discover comfort levels in	media explorations	materials
materials and media	relaxation exercises	media
creativity	concentration exercises	composition principles
train experiences	message decomposition	laws of colour, contrasts
train perceptions	practical-theoretical	laws of form
courage	sensory stimulation and	line
remove deadwood of	training the senses	shape
convictions	develop four successive	space
explore	fields: geometric-intuitive;	movement
intuition	gestalt; topological; and	volume
produce or execute with	phenomenological	formal coherence
quality	transformational geometry:	modularity
express design elements in	Euclidean; affine and	symmetry theory
various media and	projective; topological; and	morphogenesis
techniques	set theory	closepacking
abstract		

The selection of the design study programs resorted to an on-line institutional list[15] with all the Portuguese HE Design study programs (i.e., that mentioned Design in the designation). The list consisted of a total of 61 design study programs, being 39 from public institutions, including universities and polytechnics, and 22 from private universities and polytechnics. Data collection took place during the academic year 2016-17 and referred to that ongoing period.

4.3.2. Learning outcomes of the BD courses

After identifying the BD-derived courses in the Portuguese context, we proceeded with the analysis of the LOs present in the respective study plans, for the creation of a conceptual frame. It focused the main dimensions (i.e., levels of understanding and content topics) as defined in the constructive alignment theory. This provided the basis for a second objective – the definition

[15] http://www.dges.mctes.pt/DGES/pt/estudantes/rede/ensino+superior/estabelecimentos/rede+privada retrieved January 2017; and http://www.dges.mctes.pt/DGES/pt/Estudantes/Rede/Ensino%20Superior/Estabelecimentos/Rede%20P%C3%BAblica/ retrieved January 2017

of the prominent combinations between levels of understanding and content topics, also considering the subcategories of both dimensions.

Therefore, the task was addressed in two successive moments, for which we adopted the same qualitative methodological approach (Neves, Dias, Duarte, et al., 2019; Neves, Dias, Ramalho, et al., 2019), using MaxQDA software for the content analysis of the study plans from the Portuguese BD-derived Curricular Units.

Sample

Forty-three study plans of the courses identified as carrying the BD tradition in the Portuguese design courses (Neves, Dias, et al., 2018), were analysed for identifying the LOs, here classified according to the economic sector of the institution, HE system, and type of course.

Instruments

We analysed the study plans marking the different concepts and creating categories and subcategories along the way, which enabled successive refinements. Therefore, the lexical-conceptual matrixes, firstly presented by Neves et al. (2019), were subsequently adjusted for the purpose of the microanalysis, as noticed by the authors (Neves, Dias, Ramalho, et al., 2019). Both lexical conceptual matrixes are presented in Figures 17 and 18, respectively referring to the levels of understanding and content topics. The levels of understanding address: low(1)-uni-structural; low(2)-multi-structural; high(3)-relational; high(4)-extended abstract; and undefined, are derived from the constructive alignment theory, to which are added a numeric code (1 to 4). We created the undefined level for all the verbs considered ambiguous or doubtful, that could not be classified. The pre-structural level being the lowest and standing for non-existing competence, in the constructive alignment theory, has no verb associated to that level. For that reason, we didn’t use it in our matrix. For the content topics matrix, we followed similar criteria for coding. We used a code composed by letters (A to G) and numbers according to a category and, sometimes, a subcategory. The main categories are: (A)-communication; (B)-design fundamentals; (C)-means and techniques; (D)-personal values and skills; (E)-historical, economic, social, cultural context; (F)-project-methodology; and (G)-undefined. This last category includes all the content topics that we considered ambiguous.

Procedure

For the qualitative analysis we used blocks of text from the Portuguese BD study plans, previously coded using MaxQDA software analysis, already categorized according to the presented conceptual matrixes.

The connections between the two dimensions of the LOs (Verbs & Content Topics) were made using two procedures: (i) in the case of the sublevels, by selecting the codes and using the combine function in MaxQDA; and (ii) using excel files as they allow more flexible search by using simultaneous filters.

4.4. Results

The mapping of BD in the Portuguese HE scenario was gradually developed for allowing the identification of LOs on the BD courses.

4.4.1. Pre-selection of BD-based Curricular Units

The pre-selection phase resulted in the selection of 61 design courses' curricular programs, available at the institutions' websites, in which were identified the courses with high workload/ECTS (e.g., there were pre-selected the following curricular units from the first-year curricular programme of a given design course: Generic_2-Design I; and Generic_2-Design II-Generic_2), and that used designations somehow indicative of BD characteristics.

The study plans were searched at the institutional websites and, when not available, a formal request was sent to the respective institution. From a total of 48 bachelor's in design programs, 28 are from public institutions, and 16, from private institutions. From a total of 91 study plans gathered, 61 are from public institutions, and the remained 30 from private institutions. The analysis was not possible for 16 courses due the lack of information and, in a few cases, due the discontinuation of the study program.

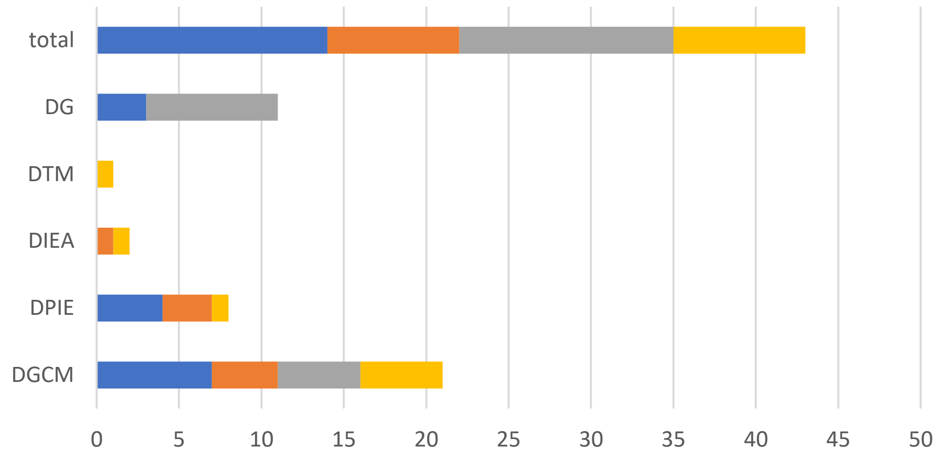
4.4.2. Selection of BD-based Curricular Units

Forty-three study programs were analysed. As resumed in Table 4, the study plans were considerably reduced after the analysis, causing also, a reduction on the design study programs with BD characteristics.

Table 4. Pre-selection and selection phase of the study plans.

	Pre-selected study plans (based on the website info)				**Selected study plans (after detailed analysis)**			
	Public		Private		Public		Private	
	design study programs	study plans	design study programs	study plans	design study programs	study plans	design study programs	study plans
Generic	4	10	6	9	2	3	6	8
DPIE	8	18	1	1	6	7	1	1
DTM	2	4	1	1	0	0	1	1
DIEA	2	5	1	1	1	1	1	1
DGCM	12	24	7	18	9	11	6	10
Total	**28**	**61**	**16**	**30**	**18**	**22**	**15**	**21**

In Figure 16 below we can see the distribution of the Portuguese BD courses according to the economic sector, HE system, and type of course.



	DGCM	DPIE	DIEA	DTM	DG	total
Public University	7	4	0	0	3	14
Public Polytechnic	4	3	1	0	0	8
Private University	5	0	0	0	8	13
Private Polytechnic	5	1	1	1	0	8

Figure 16. Basic design in the Portuguese design courses (frequency).

It is interesting to note that only one course specifically mentioned Basic Design in its name (i.e., DPIE_6 Projet in Basic Design[16]). The other courses used terms such as: DGCM_15 Form and Colour e Cor[17]; DGCM_17 Introduction tosign[18]; DIEA_1 Laboratory of Matter and Form.[19]

4.4.3. Eliminating bias.

The initial list of study plans was revised to purge any dubious cases that might have escaped the first filtering. Thus, the study plans identified as containing content topics related to BD (e.g., the basic elements of the visual language: form, plane, surface, colour, space, volume, mass, scale, high, matter, light, shadow, texture; and its organization principles), but standing alone next to other non-related to BD, were not selected. Such was the case of DGCM_1- Drawing[20], since the focus was clearly on the drawing abilities, techniques, and materials. The same happened with DGCM_1 Design 3D as it addressed the development of a specific mode of digital representation.

Another factor of exclusion of the already pre-selected study plans was a strong project character (e.g., DGCM_8 Communication Design[21] II; Generic_3 Design II; DGCM_13 Communication Design I[22]; and others). All study plans in which there was a predominance of design thinking and practice, with results centred on objects, and the absence of an experimental approach to the fundamentals of design were also excluded. The same situation was verified for theoretical approaches, as in Generic_1 Theory and Practice of Design[23], or at DGCM_15 Projet and Methodology[24]

[16] Free translation from the original Projeto em Design Básico

[17] Free translation from the original Forma e Cor

[18] Free translation from the original Introdução ao Design

[19] Free translation from the original Laboratório de Matéria e Forma

[20] Free translation from the original Desenho

[21] Free translation from the original Design de Comunicação

[22] Free translation from the original Design de Comunicação I

[23] Free translation from the original Teoria e Prática do Design

[24] Free translation from the original Projeto e Metodologia

4.4.4. Learning Outcomes of the Basic Design courses

This study resulted in two conceptual matrixes of the levels of understanding, which can be seen in Figure 17, and of the content topics, in Figure 18. These are indicative of the components of the Portuguese LOs, detailed in categories and subcategories.

low(1)-unistructural	**high(3)-relational**	**high(4)-extended abstract**
(1)1_sensitize	(3)1_manage	(4)1_gain autonomy
(1)2_define	(3)2_express	(4)2_strictly master
(1)3_identify	(3)3_synthesize	(4)3_transform
(1)4_represent; draw; operate; exercise	(3)4_project	(4)4_reflect
(1)5_awake; introduce	(3)5_interpret	(4)5_create new concepts
(1)6_recognize	(3)6_explain; justify	(4)6_substantiate
	(3)7_integrate; merge; articulate	(4)7_design
low(2)-multistructural	(3)8_criticize; judge; decide	(4)8_create; compose
(2)1_experiment; explore	(3)9_organize	
(2)2_acquire habits	(3)10_plan	
(2)3_systematize	(3)11_build up	**Undefined level**
(2)4_differentiate; structure	(3)12_solve problems	(0)1_understand; to know
(2)5_describe; communicate	(3)13_analyze	(0)2_develop
(2)6_present results	(3)14_defend; argue	(0)3_vague
	(3)15_apply	(0)4_no content

Figure 17. Matrix of the levels of understanding.

- **(A)communication**
  - (A)1_general communication
  - (A)2_visual communication
  - (A)3_concepts
  - (A)4_perception
  - (A)5_representation; expression
- **(B)design fundamentals**
  - (B)1_colour
    - (B)1.1_general colour
    - (B)1.2_elements
    - (B)1.3_composition; structure
    - (B)1.4_function
    - (B)1.5_theory
  - (B)2_shape
    - (B)2.1_general shape
    - (B)2.2_3D shape
    - (B)2.3_2D shape
    - (B)2.4_theory
    - (B)2.5_function
    - (B)2.6_composition; structure
  - (B)3_fusion fundamentals
    - (B)3.1_theory
    - (B)3.2_function
    - (B)3.3_composition; structure
    - (B)3.4_relations
- **(C)project**
  - (C)1_project; methodology; product
- **(D)means and techniques**
  - (D)1_analogical
    - (D)1.1_general means and techniques
    - (D)1.2_painting
    - (D)1.3_mockups
    - (D)1.4_typhography
    - (D)1.5_drawing
    - (D)1.6_modeling
    - (D)1.7_handcraft
    - (D)1.8_plastic/graphic expression
    - (D)1.9_prototype; model
    - (D)1.10_photography
    - (D)1.1_paintingmaterials
  - (D)2_analogical-digital
- **(E)personal values and skills**
  - (E)1_work process
    - (E)1.1_teamwork
  - (E)2_communicate
  - (E)3_self-knowledge; self-critique
  - (E)4_interdisciplinarity; multidisciplinarity
  - (E)5_autonomy
  - (E)6_learn
  - (E)7_critique
  - (E)8_analysis; reflection
  - (E)9_observation; to see
  - (E)10_creativity; curiosity
  - (E)11_delivery term
- **(F)contexts (historical; economic; social; cultural)**
- **(G)undefined content**

Figure 18. Matrix of the content topics.

The three most frequent combinations between the main dimensions of LOs: levels of understanding (actions/verbs) and content topics (objects/content), are at the high(3)-relational level, combined with the content topic (B)-design fundamentals (79.1%), (E)-personal values and skills (60.5%), and (C)-Project (55.8%) as observed in Figure 19. Can be also evidenced that the content topic (B)-design fundamentals (53.5%), combined with the low(1)-unistructural level, stands for the 4th most frequent combination.

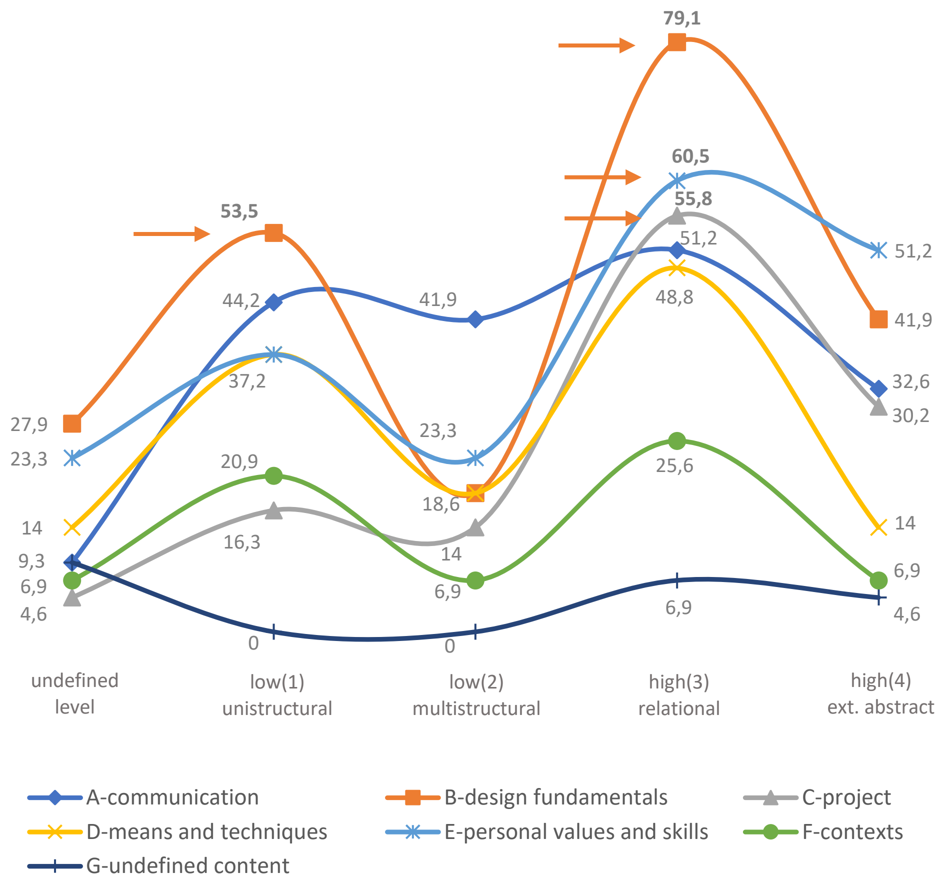


Figure 19. Frequency of connections between levels of understanding and content topics (%).

The following, Figures 20 and 21, address the high(3)-relational and low(1)-unistructural sublevels, pointed as the most frequent levels of understanding.

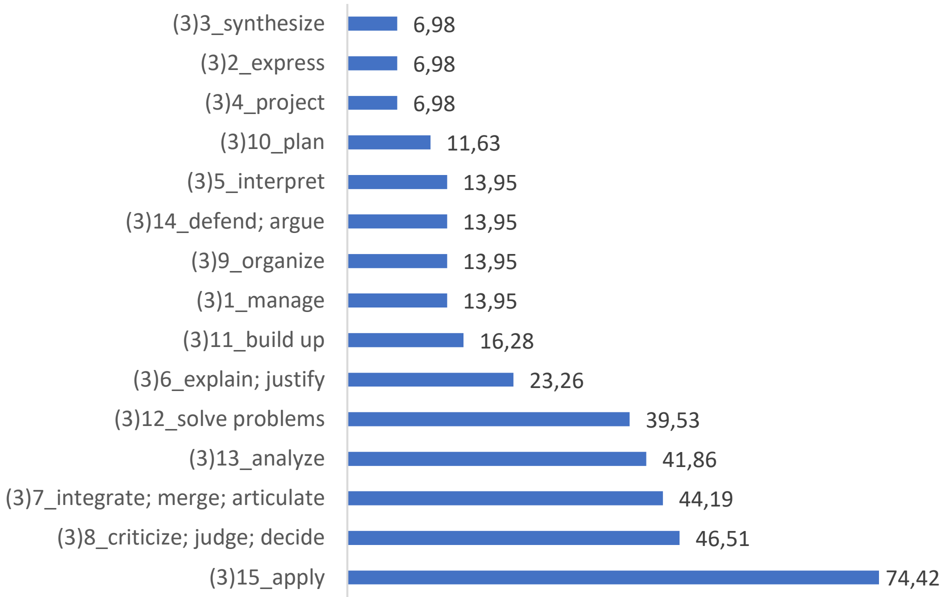


Figure 20. Sublevels of high(3)-relational in study plans (%).

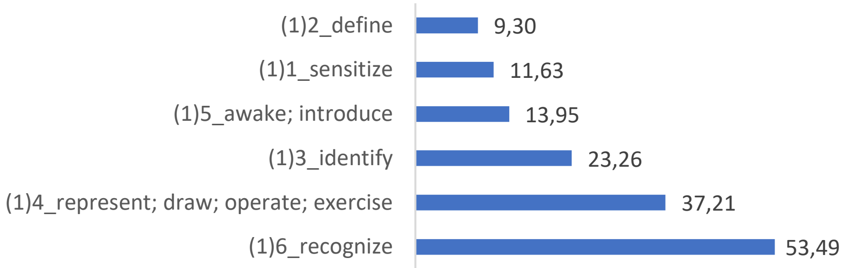


Figure 21. Sublevels of low(1)-uninstructural in study plans (%).

Level high(4)-extended abstract, with the sublevels presented by frequency in Figure 22, is the third most represented level of understanding. In this level, the most frequently identified verb is (4)8_create; compose (34,88%).

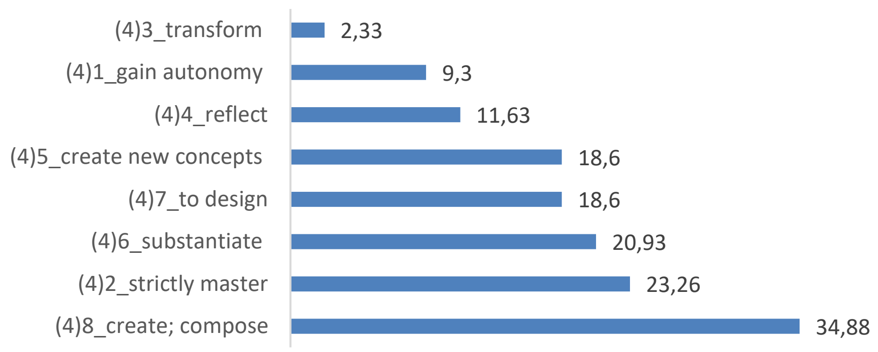


Figure 22. Sublevels of high(4)-extended abstract in study plans (%).

Regarding the content topics matrix, (B)design fundamentals is the most frequent content topic. In the respective subcategories, (B)2_shape presents the highest frequency (76%) followed by (B)3_fusion fundamentals (65%), and then by (B)1_colour (30%), as shown in Figure 23.

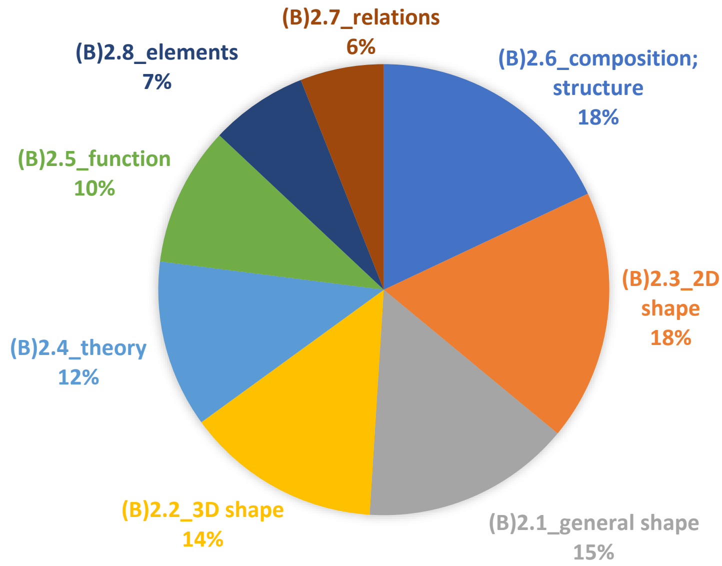


Figure 23. Content topic sublevel (B)2_shape, in study plans (%).

The second most frequent content topic relates to (E)-personal values and skills, that is presented with all the sublevels in Figure 24.

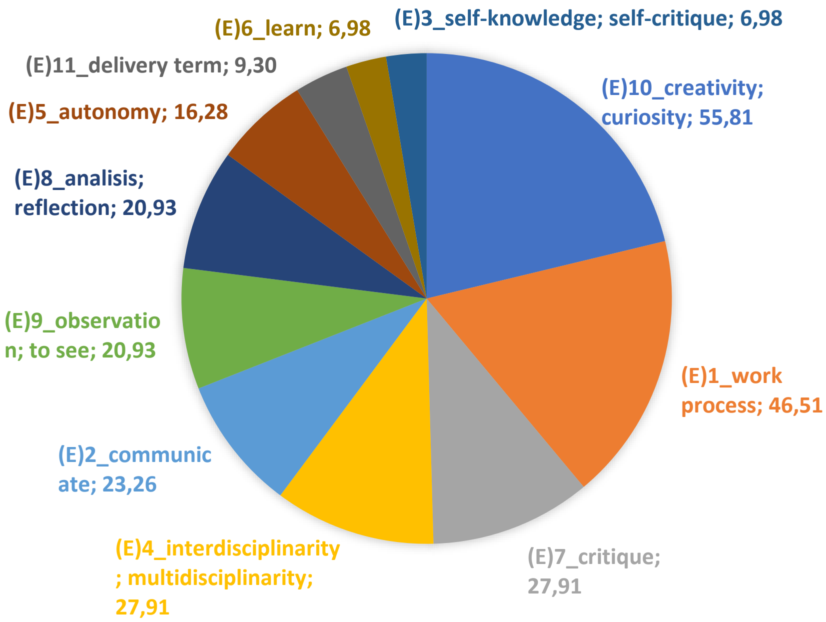


Figure 24. Content topic (E)-personal values and skills, in study plans (%).

The micro-analysis to the LOs of the Portuguese BD courses allowed the identification of the most frequent combinations between the two dimensions of LOs: levels of understanding (actions/verbs) and content topics (objects/content), as presented in the respective conceptual matrixes. Accordingly, the high(3)-relational level, combined with the content topic (B)-design fundamentals, was found to be the most frequent. It follows the combination using high(3)-relational level, with the content topic (E)-personal values and skills.

Based on the analysis carried out, here are some examples of the three most frequent combinations, illustrated above in the Figure 19, using the high(3)-relational level, with (B)-design fundamentals, in Table 5, followed by (E)-personal values and skills, in Table 6, and (C)-project, in Table 7.

Table 5. High(3)-relational x (B)-design fundamentals.

evel X Content Topic	Learning Outcome	Study Plan
high(3)-relational\(3)11_build up x (B)-design fund.\(B)2_shape\(B)2.6_composition; structure	"Plan the procedures needed to build less complex shapes or systems"	4 DPIE
high(3)-relational\(3)9_organize x (B)-design fund.\(B)2_shape\(B)2.6_composition; structure	"Develop the ability to organize the elements that structure two-dimensional discourse"	43 DGCM

Table 6. High(3)-relational x (E)-personal values and skills.

Level x Content Topic	Learning Outcome citation	Study Plan
high(3)-relational\ (3)12_solve problems x (E)-per. values and skills\ (E)10_creativity; curiosity	"Appreciation of the process as a creative means for the discovery of new original solutions…"	11 DPIE
high(3)-relational\(3)15_apply x (E)-personal values and skills\ (E)10_creativity; curiosity	"Use of creativity innovation strategies"	40 G

Table 7. High(3)-relational x (C)-project.

Level x Content Topic	Learning Outcome citation	Study Plan
high(3)-relational\(3)15_apply x (C)-project\ (C)1_project; methodology	"ability to use a methodology"	2 DIEA
high(3)-relational\(3)15_apply x (C)-project\ (C)1_project; methodology	"implementation of procedural methodologies"	16 DGCM

The second most frequent level verified in the LOs was low(1)-unistructural level, being present in 83,72% of the study plans. This may be due to the fact that it taught during the first semester of the design courses and, therefore does not require a in-depth knowledge at this stage of learning (Biggs & Tang, 2007). The combination between low(1)-unistructural level with (B)-design fundamentals is the fourth most represented content in the study plans, for which we present some examples of LOs that point to this relationship (see Table 8).

Table 8. Low(1)-unistructural x (B)-design fundamentals.

Level x Content Topic	Learning Outcome	Study Plan
low(1)-unistructural\ (1)6_recognize x (B)-design fund.\ (B)3_fusion fund.\(B)3.4_relations	"Recognize the concepts of measurement, scale, proportion and hierarchical relationship…"	25 DGCM
low(1)-unistructural\(1)3_identify x (B)-design fund.\(B)3_fusion fund.	"Identify the key elements of the field and visual language in the image, space, form and typographic font"	27 DTM

The high(4)-extended abstract level is the third most frequent level found in the LOs present in the Portuguese BD study plans. The LOs that use this level are indicative of the contents that are expected to be performed at the highest cognitive level, thus revealing them as the most important to be learned and, therefore, essential for the course (Biggs, 2003). As can be noticed, those content topics are (E)-personal values and skills, followed by (B)-design fundamentals, 51,2% and 41,9% respectively, pointing them as the most important to be learned (see tables 9 and 10).

Table 9. High(4)-extended abstract x (E)-personal values and skills.

Level x Content Topic	Learning Outcome citation	Study Plan
high(4)-extended abstract\ (4)1_gain autonomy x (E)-per. values and skills\ (E)10_creativity; curiosity	"Developing student creativity and autonomy and understanding the broad concept of design"	39 G
high(4)-extended abstract\ (4)8_create; compose x (E)-per. values and skills\ (E)7 _critique	"Create with authenticity and critical sense"	23 DGCM

Table 10. High(4)-extended abstract x (B)-design fundamentals

Level x Content Topic	Learning Outcome citation	Study Plan
high(4)-extended abstract\ (4)5_create new concepts x (B)2_shape\(B)2.3_2D shape	"Establish proportional relationships between parts and whole while safeguarding harmony and balance..."	28 DGCM
high(4)-extended abstract\ (4)5_create new concepts x (B)2_shape\(B)2.1_general shape	"Capacity for formal and plastic abstraction"	2 DIEA

As observed, the most important content topics (i.e., the ones combined at the highest level of understanding, high(4)-extended abstract) were also the most frequent, despite appearing in reverse order (i.e., firstly, (E)-personal values and skills, followed by (B)-design fundamentals).

Likewise, we also highlight the most frequent subcategories of content topics, such as (E)10_creativity; curiosity, in (E)-personal values and skills; and (B)2_shape\(B)2.6_composition; structure, in (B)-design fundamentals. The results also confirm the idea advanced by Biggs and Tang (2007) that in HE systems the outcomes would be predominantly high-level.

4.5. Chapter Summary

This study has given us a perspective of the LOs present in the BD courses that currently exist in the context of HE design education in Portugal. The existence of Portuguese BD courses was confirmed, identified, and categorized by economic sector, HE system, and type of course. Also, the LOs present in the courses were defined in its main components (i.e., levels of understanding and content topics) according to the constructive alignment theory, thus enabling the identification of the prominent combinations between levels of understanding and content topics used in the Portuguese BD courses. Also identified were the categories and subcategories of both components, presented as the conceptual matrixes of levels of understanding and of content topics of the Portuguese BD education.

4.5.1. Mapping BD in the Portuguese Higher Education scenario

A conceptual matrix for identifying the presence of BD tradition in Portuguese design education was created and applied to each of the selected study plans to highlight the presence of BD in the Portuguese Higher Education system. This analysis revealed a total of 33 design study programs (18 in public sector and 15 in private sector) that have courses that continue BD tradition, which resulted in the selection of 43 courses (22 in the public sector and 21 in the private sector) that were included in the study.

The analysis also allowed us to conclude that, despite the common use of various software and multimedia being a popular resource, there is an almost complete absence of new technologies such as Virtual Reality in use in these courses. There is also an absence of contemplative practices, such as breathing and concentration exercises, as practiced in the original *vorkurs* (Itten, 1975). This can be penalising because both have been evidencing positive contributions to learning Design related contents. In addition, we have also observed that social media platforms are rarely mentioned in pedagogical practices, despite being recognised as very useful for promoting discussion between the groups of students, or simply, a form of delivering the exercise for assessment by teachers. (e.g., DPIE_6 Project in Basic Design[25], mentions the platform FLICKR).

Although breathing and concentration exercises are currently absent from the Portuguese BD-derived courses, we suggest that designers could benefit from the revival of this lost anchor point in design pedagogy. At its early days, one of the main aims of Basic Design was the development of intuitive thinking. Nowadays, intuition has a lot of added value, as it can help the comprehension of complex systems in which all human activities are involved, from medicine to law (Findeli, 1994). Over time, this intention has been lost, giving rise to more rational and formalistic exercises. Nonetheless, the presence of some elements in the study plans that could be related with contemplative practices should be emphasised. For example, the course DPIE_6 Projeto em Design Básico, requires a diary where students progressively record their work, which, if properly used, could promote self-reflection and self-discovery through observation of one’s work, without corrections or revisions, characteristic of contemplative pedagogical practices. As Design should promote human flourishing (i.e., offer design experiences that give people a sense of well-being related to the feeling of being aligned

[25] Free translation from the original Projeto em Design Básico

with values and ideas that positively contribute to a common good (Desmet et al., 2013) would we all benefit from adding contemplative methodologies and techniques to the current design teaching-learning activities?

Besides allowing us to identify the LOs and its components, the study plans also inform us about the bibliography currently adopted in the BD courses. This information can add to a deeper understanding of philosophy and learning theories underlying the courses individually and in the general context of Design education in Portugal.

One last reflection for the future: Marcolli (1971) and Munari (1995) have once reinforced the need for intensely exercise and explore the elements of design and their combinations through a propaedeutic training, although this goes against young people's desire for quick results, that is, the immediate creation of products. Presently, a significant number of study plans have adopted a project-based approach. Some of the study plans selected include abstract exercises and a final project. Is this approach leading to better results in learning of the design fundamentals?

4.5.2. Learning outcomes of the Basic Design courses

The second part of the study consisted of a micro-analysis of the LOs of the Portuguese BD courses. It allowed to identify the most frequent combinations between the two dimensions of LOs: levels of understanding (actions/verbs) and content topics (objects/content) as presented in the respective conceptual matrixes. Accordingly, the high(3)-relational level, combined with the content topic (B)-design fundamentals, was found to be the most frequent. It is followed by the combination of using high(3)-relational level, with the content topic (E)-personal values and skills.

We improved the conceptual matrixes previously created and enriched the conceptual frame. It allowed the definition of the levels of understanding and the content topics presented in the LOs for the purpose of conducting the subsequent micro analysis. The conceptual matrixes represent, in some way, the structure of the Portuguese BD course, in terms of the mentioned LOs components. Simultaneously, they reveal a hierarchic conceptualization that can be useful for structuring the learning design of BD courses.

The combinations of the levels of understanding and the content topics showed that content topics related to personal values and skills and design fundamentals are common, both in terms of frequency and importance. We found that the Portuguese BD context, like the *preliminary* course, reaffirms the importance of these contents, making them more recommended for integrating BD learning tools in a fundamental basis.

We could move on from here to develop a tool that considers a common minimum structure, informed by the most prominent combinations of levels of understanding and content topics. The minimum structure could address the combinations: level of understanding high(3)-relational with contents (E)-personal values and skills and (B)-design fundamentals; level of understanding low(1)-unistructural with (B)-design fundamentals; and level of understanding high(4)-extended abstract with (E)-personal values and skills. Further developments of the micro-analysis could consider assigning hierarchical values to each combination. This would add to the development of a common minimum structure shared by BD courses worldwide, adaptable to different spaces, places, circumstances, mediums, times and learning ages. It could serve various design areas, teaching methodologies and pedagogical approaches. Finally, it could support the development of student-centred learning design tools that considers students' interests, talents and creative power in the process of becoming a designer. Each student can declare their preference for a specific design area of more than one, enabling the highest possible level of understanding topics of design fundamentals such as: formal coherence, harmony, or symmetry. If provided by an immersive virtual environment, like, the experience can also allow learning to take place from direct experience, as in the real-world experiences. If considered in alignment with programme outcomes and graduate attributes, this micro scale analysis opens the opportunity for the creation of BD learning tools and experiences guided by the significant LOs for all designers that take in consideration the unique characteristics of each individual person.

4.6. References

Agapito, D., Almeida, H., Cesário, M., Fernandes, S., & Lacerda, A. (2015). *Design em Portugal – O perfil do designer e o papel do design nas empresas em Portugal*. Sílabas & Desafios.

Almeida, V. (2009). *O Design em Portugal, um Tempo e um Modo. A institucionalização do Design Português entre 1959 e 1974* [Doutoramento, Faculdade de Belas Artes, Universidade de Lisboa].

http://repositorio.ul.pt/bitstream/10451/2485/2/ulsd059655_td_Tese_Victor_Almeida.pdf

Biggs, J. (2003). Aligning Teaching and Assessment to Curriculum Objectives. *Proceedings of the International Conference on Teaching and Learning in Higher Education*. International Conference on Teaching and Learning in Higher Education: New Trends and Innovations, Aveiro, Portugal, 13-17 April 2003, Aveiro, Portugal.

Biggs, J., & Tang, C. (2007). *Teaching For Quality Learning At University* (Edição: 3). Open University Press.

Bonsiepe, G. (1992). *Teoria e prática do design industrial: Elementos para um manual crítico* (1992nd-1ª ed portuguesa ed.). Centro Português de Design.

Costa, D. da. (2001). *Curriculum Vitae*.

Desmet, P., Pohlmeye, A., & Forlizzi, J. (2013). Design for Subjective Well-Being. *International Journal of Design*, *7*(3), 1–3.

Dias, D. (2017). Learning Outcomes in European Higher Education. In P. Texeira & J. Shin (Eds.), *Encyclopedia of International Higher Education Systems and Institutions* (pp. 1–5). Springer Netherlands. https://doi.org/10.1007/978-94-017-9553-1_317-1

Findeli, A. (1994). Ethics, Aesthetics, and Design. *Design Issues*, *10*(2), 49–68. https://doi.org/10.2307/1511628

Itten, J. (1975). *Design and Form: Basic Course at the Bauhaus* (Revised edition edition). Titles Supplied by John Wiley & Sons Australia.

Marcolli, A. (1971). *Teoria del Campo—Corso di educazione alla visione* (1998th, 17ªed ed.). Sansoni Editore.

Marcolli, A. (1978). *Teoria del Campo 2—Corso di metodologia dalla visione* (1991st, 3ª ed. ed.). Sansoni Editore.

Moholy-Nagy, L. (1947). *Vision in Motion*. Wisconsin Cuneo Press.

Munari, B. (1979). *Arista e Designer*. Editorial Presença/Martins Fontes.

Munari, B. (1995). *Design e Comunicação Visual*. Edições 70.

Munari, B. (1998). *Design e Comunicação Visual* (1 edition). Martins Fontes.

Neves, A. G., Dias, D., & Duarte, E. (2018). As Basic Design promotes the Design Learning: Featuring the Portuguese Higher Education setting. *ICERI2018 Proceedings*, 7663–7671. https://doi.org/10.21125/iceri.2018.0376

Neves, A. G., Dias, D., Duarte, E., & Ramalho, J. (2019). Back to the Basics of Basic Design: The Portuguese Scenario. *Proceedings of the 12th Annual International Conference of Education, Research and Innovation - ICERI'2019*, 416–425. https://doi.org/10.21125/iceri.2019.0139

Neves, A. G., Dias, D., Ramalho, J., & Duarte, E. (2019). Micro influence of Learning Outcomes in Basic Design. In E. Duarte & C. Rosa (Eds.), *Proceedings of the UNIDCOM 10th International Conference* (pp. 26–38). Edições IADE, Universidade Europeia.

OECD. (2012). *Assessment of Higher Education Learning Outcomes AHELO. Feasibility Study Report*, *vol 1 – Design and Implementation* (volume 1).

Chapter V

In short, universities have forgotten their larger educational role for college students. They succeed, better than ever, as creators and repositories of knowledge. But they have forgotten that the fundamental job of undergraduate education is to turn eighteen- and nineteen-year-olds into twenty-one- and twenty-two-year-olds, to help them grow up, to learn who they are, to search for a larger purpose for their lives, and to leave college as better human beings.

H. Lewis

5. A conceptual framework-model for Basic Design learning activities

5.1. Abstract

It is well established that learning activities are key factors to afford students ways of becoming designers capable of addressing complex, unpredictable and mutable challenges. We advocate that Basic Design represents a decisive starting point in design education, by which the freshmen are formally introduced into the process. In its original version, BD pedagogy is grounded on a holistic approach that requires the development of all human dimensions: body-mind-spirit, which was redirected towards action-perception-aesthetics in the last century turn. In today's times of technological disruption, constant changes are needed in BD learning activities, for which we can't find a framework-model in the literature to help with the task. This gap led us to develop a conceptual framework-model to i) upstream, guide teachers and learning designers in analysing and criticizing present learning activities, in making systematic adaptations, adjustments and, even, profound transformations in setting of new learning activities; ii) and downstream, engage the freshmen in learning experiences that awakens them to a meaningful life-learning journey, in-through design. In this study we present the theoretical background on which our conceptual framework-model is grounded. It articulates the macro and micro pedagogic scales, respectively, the philosophical premises of the original BD, and

the Learning Outcomes (LOs), as a way of corresponding to the contemporary Higher Education (HE) systems requirements. Prior and independently of considering the use of digital technology in BD learning activities, the conceptual framework-model is the first attempt in the field to support the design of learning activities in BD that correspond to the LOs, which are aligned with a holistic approach to teaching and learning the design fundamentals. In this sense, it can support students' individual talents and paths, thus preparing them to tackle complex socio-technical problems in their future professions.

5.2. Chapter Introduction

There is now a widespread agreement on the need to change design education (Meyer & Norman, 2020, p. 14) and to deliver new design curricula that "focus on intellectual flexibility and concern for human values that are characteristic of the earliest design practices" (Davis, 2017, p. 34). The accelerating technological transformation and exacerbating environmental problems bring questions about how to prepare young people to become designers in a complex systems culture (Frascara, 2020; Meyer & Norman, 2020; Norman, 2016; Redström, 2020). Special consideration is given to how digital technology will impact the times to come, largely due to the integration of biotech and infotech in individual and collective spheres. We could not predict however how quick the change would be imposed. COVID-19 pandemic protective measures forced new priorities, diminished the resources, and conditioned presential interactions, thus increasing the preponderance of digital technology while testing our capacity to reframe and reinvent our lives in most areas of society.

Education in general and design education particularly are pressing areas of intervention, demanding for remote learning contexts and better digital technological solutions. This adds to the main general goal of education, which is to provide an awakening moment and enabling a life worth living (Frascara, 2020, p. 116). Buchanan points it as an "intellectual preparation for life-long learning that cultivates the capabilities of the mind to encounter new situations and respond with ingenuity, imagination, and creativity" (Frascara, 2020, p. 109). These were the characteristics mostly sought at the Bauhaus *vorkurs* that ended up establishing the domain of lifetime design learning for the future (Lerner, 2005, p. 223). In its original premises, BD aspired to "form each young man in such a way that he develops in an original way, characteristic of himself so that he continues to be a creator," (Wick, 1993, p. 101) as a means to achieve the required balance between science-technology and spirit (Itten, 1975).

The systemic turn brought by the postmodern era, in the middle of the 20th century, affected design practice and design education (Findeli, 1990, p. 18) that had to confront the rapid change undergoing in science and technology and its impact on the larger social and environmental scales. The predominant model of craft design education moved "into a way of thinking and problem discovery to enhance individual human lives, to vitalize the experience of work, and even to improve the health of the planet" (Norman, 2016, p. 343). Towards an amplified scope of design intervention in society and increased wicked challenges, designers must engage in systemic thought (Nelson, n.d.;Nelson & Stolterman, 2012) enabling them to act as "integrators and generalists who can help to put the contribution of each discipline into systemic relationships and help to contextualize the contributions made by the specialists" (Wahl, 2016, p. 63).

Accordingly, changes are also expected in BD, an introductory course in the design undergraduate curricula, decisive for supporting the long way of design education. Furthermore, BD course holds the potential to contribute to what was recently stressed as a central core that grounds all designers prior to specialization (Meyer & Norman, 2020, p. 20). Defied and inspired by this scenario, we wanted to offer a conceptual framework-model for delivering BD activities. The theoretical background of the framework-model is presented, for which largely contributed the experience as BD teacher of the author (PhD candidate), at a Portuguese Faculty of Design: Technology and Communication – IADE, Universidade Europeia. This proposal intends to relate the macro-scale pedagogic elements, considered under the philosophy underlying the structure of the original BD courses, and the micro-scale elements, such as the components of the Learning Outcomes (LOs) (i.e., verbs and content topics) as required by the Higher Education (HE) system worldwide. The conceptual framework-model conveys the need, verified in our teaching practice, to establish coherence between the objectives of a BD course and the multiple learning activities that contribute to achieving those purposes. Therefore, the underlying structure of some BD pedagogical approaches is uncovered, evidencing their potential to assist the design of BD learning activities that meet the demands of future design education in an increasingly complex world. The conceptual framework-model is not intended to be a specific BD course or curricular unit.

Instead, we propose a reflection on how BD can be reformulated and made accessible to everyone, serving the endeavour of preparing young adults to become designers.

5.2.1. Basic Design

The Bauhaus Design School (1919-1933) revolutionized global design education with its basic design course, known as the vorlehre or preliminary course. This course, considered a cornerstone of Bauhaus (Bonsiepe, 2012), remains vital in design education today (Bayirli, 2015; Boucharenc, 2006a). It focuses on fundamental design principles, often described as design patterns (Bonsiepe, 2007). This Art and Design-based approach emphasizes aesthetic creativity and expression (Besgen et al., 2015), using exercises in colour, composition, and texture to cultivate aesthetic sensibility. The emphasis is on abstract forms that reveal essential relationships, disregarding technical and functional factors (Bonsiepe, 2012).

Based on the literature review, already referenced in Chapter II, we identified a set of key ideas that we consider the basis for creating a framework to support a new VR tool for a BD course that incorporates the principles and philosophies of the Bauhaus and subsequent developments in design education.

- Awakening Creative Potential: The Bauhaus Basic Design course aimed to awaken the creative talents of students, enhance their originality, and free their imagination, fostering creativity (Itten, 1975).
- Holistic and Experimental Methodology: The course employed a holistic, creative, and experimental approach that focused on elements such as shape, colour, texture, light, and rhythm through aesthetic and formal exercises (Itten, 1975).
- Inner Exploration: Students were encouraged to access their inner experiences, perceptions, and creative forces to break free from preconceptions and gain confidence in expressing themselves freely.
- Unique Self-Discovery: Through experimentation with various materials and mediums, students were expected to discover their unique characteristics, which could help them make informed career choices (Itten, 1975).
- Form and Colour Principles: The course emphasized understanding the principles of form and colour in composition, which could be applied in both objective and subjective contexts (Itten, 1975).

- Promotion of Intuition: Itten’s course aimed to promote higher perception and intuition by liberating students from limiting beliefs, helping them discover their genuine creative essence (Itten, 1975).
- Influence of Eastern Philosophy: The course’s methodology and exercises were influenced by Johannes Itten’s spiritual beliefs, reflecting Eastern philosophy, which included a dualistic view of phenomena in the theory of contrasts (Itten, 1975).
- Innovative Pedagogical Influences: Bauhaus incorporated educational philosophies of Dewey, Floerbel, Montessori, and Rudolf Steiner, contributing to innovation in higher education teaching (Anceschi, 2010b; Cross, 1983).
- Emphasis on Experimentation: Bauhaus instructors like Moholy-Nagy and Albers emphasized learning through experimentation, trial-and-error, and abstract formal exercises as tools for understanding universal principles (Wick, 1993).
- Objective of Self-Discovery: The primary goal of the Bauhaus Basic Design course was to help students find themselves and establish a common creative foundation for future learning (Itten, 1975; Wick,1993).
- Subsequent Developments: After the Bauhaus era, Moholy-Nagy continued to develop the Basic Design model, emphasizing intuition, creativity, systems theory, and phenomenology, aiming to make students conscious of their creative power (Findeli, 1990; Moholy-Nagy, 1947b).
- Responsibility and Inner Transformation: Moholy-Nagy’s pedagogical approach focused on developing a sense of responsibility in students and leading them toward inner transformation, preparing them for the challenges of the modern world (Findeli, 1990; Moholy-Nagy, 1947b; Moholy-Nagy, 1947b).
- Ulm School Influence: The Ulm School, which followed the Bauhaus tradition, emphasized science and technology in design education, inspiring institutions worldwide (Bonsiepe, 1999).
- Global Vision: The idea of a global vision as a fundamental principle of the modern design project was highlighted, with Tomás Maldonado being a key figure associated with this concept (Bonsiepe, 1999).

5.2.2. Learning Outcomes in Basic Design courses

On the basis that learning outcomes (LOs) are crucial in higher education (HE) system, aligning with international standards (OECD, 2012), we carried out a series of studies on Basic Design (BD) in the Portuguese HE system to explore differences by institution type (universities vs. polytechnics), economic sector (public vs. private institutions), and study program (Neves, Dias, et al., 2018). LOs for BD courses were analysed based on two key components: levels of understanding and content topics, using constructive alignment theory. The most frequent LOs were associated with high(3)-relational levels of understanding, often combined with design fundamentals (B). The most important LOs, based on high(4)-extended abstract levels of understanding, centred around content topics like personal values and skills, as well as design fundamentals. Overall, we concluded that design fundamentals, particularly related to form and colour, played a significant role in BD courses (Neves, Dias, Ramalho, et al., 2019, p. 30).

5.3. Methodology

We began by presenting the BD pedagogy in its classical versions and in more recent approaches, highlighting the influence of digital technology. We proceed to point out the relevance of LOs in the context of the HE institutions. We then detailed the theoretical background of the devised conceptual framework-model, using some examples (see Figure 25). Finally, we reinforced the pertinence and relevance of reviving the premises of BD for assisting the present and future of design education and we speculated on possible ways to improve BD pedagogy.

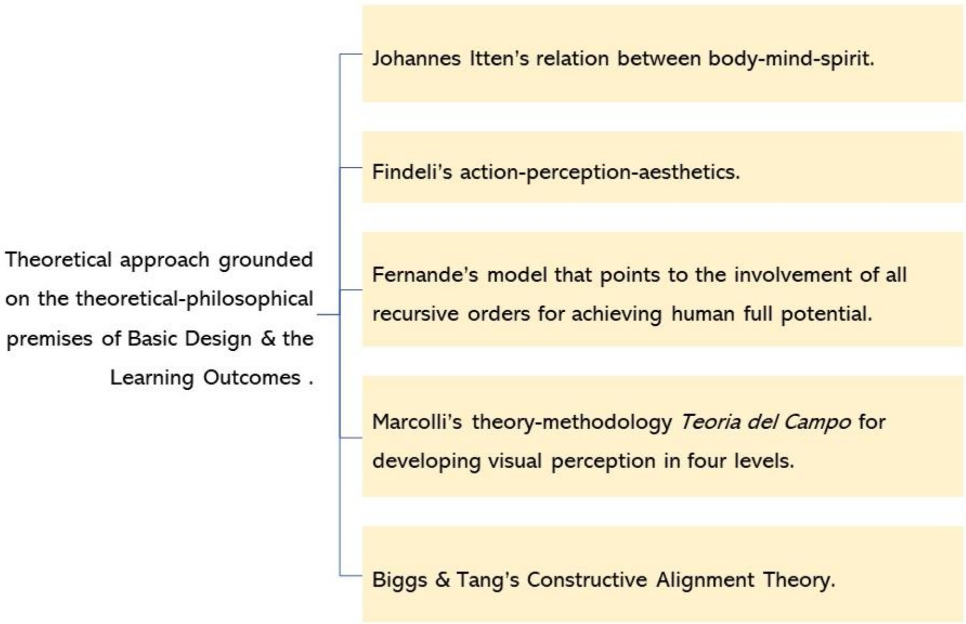


Figure 25. Diagram of the framework-model's theoretical component.

5.4. Results

BD pedagogy marked decisively design education and persists in different directions. Even after a century, the original BD theories still play a role in shaping new approaches. However, in our day-to-day teaching, we realized the need for guidance on how to create effective design of learning activities in BD that connect the holistic pedagogy with the requirements of HE systems. This connection is crucial for bridging the gap between the core principles of BD and the practical aspects of design.

Nelson and Stolterman (2012) argue that the structure of foundations, fundamentals, and metaphysics form the backbone of a design culture. We propose to establish this link using a new conceptual framework-model, and we provide a detailed theoretical background for that. It is important to note that we are not trying to simplify or merge these theories into a single concept. We recognize that these theories are rich and complex (far beyond the limits of this study), and our goal is to explore a potential relationship for the purpose of this study.

5.4.1. Components of the conceptual framework-model

The original BD course, as devised by Itten, consisted of appliyng the principle of experience-perception-practical ability. It involved the awakening a vital feeling for a given topic, starting from experience with the senses (stimulation and training of the senses); then, objectifying the topic on an intellectual level (development of logic and understanding concepts); and finally realising it through synthetic means (producing or executing with quality) (Itten, 1975, p. 12). In Findeli's opinion, the new way of seeing and being, aligned with the systemic paradigm, implies considering the archetypical model technology-science-art as action-perception-aesthetics (Findeli, 1990, p. 16). Action, in the sense that technological act is a moral act; perception is related to visual intelligence and the aesthetics refers to the reflexive link between action and perception. Thus, adequate and consistent training in ethical sensitivity, visual intelligence and aesthetical intuition are the means to transform worldviews.

Teoria del Campo

The project pedagogy developed by Attilio Marcolli (1971), detailed in the section 2.4.5., constitutes an important part of our proposed conceptual framework-model. Marcolli proposed that a unified perception is achieved through the development of four successive and cumulative fields/spaces, or ways of seeing the phenomena: geometric-intuitive; gestalt; topological; and phenomenological; applying as the transformational geometry of each field, respectively: the Euclidean; affine or projective; topological; and set theory.

Orders of recursions versus levels of understanding

The model presented by Fernandes (Fernandes, 2011) for restructuring the basic course, as previously mentioned, argues that to develop project and creative abilities it is necessary to operate the transition between all the recursive orders in the consensual coordination of actions, out of and, in the language (i.e., the human operative process). Those orders span between two modes of cognitive function: one more closely related to unconscious and bodily emotions, impulses, habits, as in spontaneous, instinctive and intuitive behaviours; and another involving conscious and intellectual mechanisms that occur in a prominently voluntary and controlled mental behaviour, thus linked to rational and regulated reflexive determinations (Fernandes, 2011, pp. 19–20). Although only the first four orders are detailed, more can follow. Accordingly, the first order relates to intuitive actions and spontaneous behaviours, such as habits. If a disturbance occurs in that level, the following level is activated for overcoming the disturbance. This passage represents the formation of the observer-object relation. Consequently, reflection and explanations of phenomena are made in a third order recursion. In the fourth order, autonomy and creativity are attained, thus affording project capacity, responsibility, and freedom. The orders of recursions, as explained by the author, apply to successive phases along the undergraduate design course. However, for our framework-model proposal, they are considered in a course level. Orders of recursions and levels of understanding (within the constructive alignment theory) address the cognitive functions.

Finally, our model is intended to address a wider cycle of development in design that surpasses the HE formative period and shall extend through professional practice. Such as in BD learning cycle, the holistic development may occur in a multiplicity of learning topics and learning levels.

5.4.2. Structuring BD learning activities

The focus of teaching is to provide students the learning environments and activities more likely to result in the achievement of LOs. The constructive alignment theory points specifically, the “need to engage the students in learning activities that directly link to achieving the intended outcomes” (Biggs & Tang, 2007, p. 7). It implies involving a whole range of high and low cognitive levels in activities that include reflecting, theorizing, creating, in the case of high levels; and memorizing, enumerating, in the case of low levels (Biggs & Tang, 2007, p. 26).

The design of learning activities is the last step to be delivered in designing a course, as considered by the stages of backward design (Wiggins & McTighe, 2005, pp. 17–18). Firstly, the desired results must be identified, in terms of goals to be attended and making clear priorities about which contents should be addressed. Secondly, must be determined how the students can manifest the understanding of those contents. Finally, learning experiences and instruction must be planned to afford the understanding of the concepts to be manifested and evidenced. Accordingly, BD activities should be developed having in mind how they will produce the evidence that the students really understand the concept defined upfront as part of the course or unit, and not simply as contents to be covered or as a series of learning activities (Wiggins & McTighe, 2005, p. 18).

To really understand a concept means to act differently in contexts involving that concept and the ability to use it in unfamiliar and novel contexts. Therefore, effective learning occurs when a change in thinking and action is evidenced, which requires repetitive activities. In this respect, BD theory is elucidative. The intensity and consistency of the abstract exploratory exercises is considered essential, in the perspectives of Marcolli and Munari (Marcolli, 1971; Munari, 1995). According to Munari (1907-1998), for effective learning is important to deepen the topics by doing as many exercises as possible (Munari, 1995, p. 22).

However, in BD original methodology, learning a specific content topic according to the principles experience-perception-practical ability required, not the mere repetition of the same activity, but performing a set of different activities that involve all human dimensions: body, mind and spirit, thus providing a widening of perspective relating the topics being addressed. It represents the involvement of all recursive orders in human development, as considered by Fernandes (2011, p. 19).

Examples in BD theory reinforce the importance of providing a variety of contexts and mediums in which a content topic is exercised, more than the repetition of one activity. As example, Moholy-Nagy's methodology in Chicago required the exercise of one given element (e.g., line, shape, colour, space, and so on) in different tools and media (Findeli, 1990, p. 9). On the same manner, Marcolli maintained along the exploration of the four successive fields (i.e., geometric-intuitive; gestalt; topological; and phenomenological) a common organization: structure of the field; composition of objects; object-field interaction; and tension and movement. Also, a similar progressive process takes place at *Laboratório de Design 3D*. The same content topics (e.g., modularity; pattern; symmetry/asymmetry; formal coherence) are used along three exercises that involve different mediums according an increasing of complexity (Neves & Duarte, 2015b, p. 275).

5.4.3. Applicability of the conceptual framework-model

The ideas discussed earlier are illustrated in the model shown in Figures 26-34. This visualization helps us to understand how content topics can be organized at different levels of knowledge, creating what we call an "Activity Unit" (AU). AUs represent learning activities proposed for the lecture. At this point is important to clarify the difference between the LOs and the AUs. LOs in the HE system indicate what students are expected achieve at the end of a full learning cycle (e.g., curricular unit, year programme and design study programme). They usually come before defining teaching-learning methods, learning experiences, activities, and tools. On the other hand, we introduced the term AUs specifically for this study to address what students are expected to achieve during their learning activities, helping to reach the LOs.

The basic structure is represented in Figure 26 where the concentric circles stand for the levels of understanding, from the 1st to the 5th level (from the centre to the periphery, respectively). Each quadrant of the circle, starting in the upper right quadrant and rotating clockwise, represent different learning activities, as in a timeline. In the upper right quadrant, the first learning activity of the lecture, relates to geometrical-intuitive field and the next activities, to the Gestalt, Topological and Phenomenological fields. The Levels of Understanding are represented by the numbers from 1 to 5: 1 – Pre-structural; 2 – Unistructural; 3 – Multi-structural; 4 – Relational; 5 – Extended-abstract. Finally, Marcolli´s perceptive fields are represented by the initials:G-I – Geometric-intuitive; G – Gestalt; T – Topologic; P – Phenomenologic.

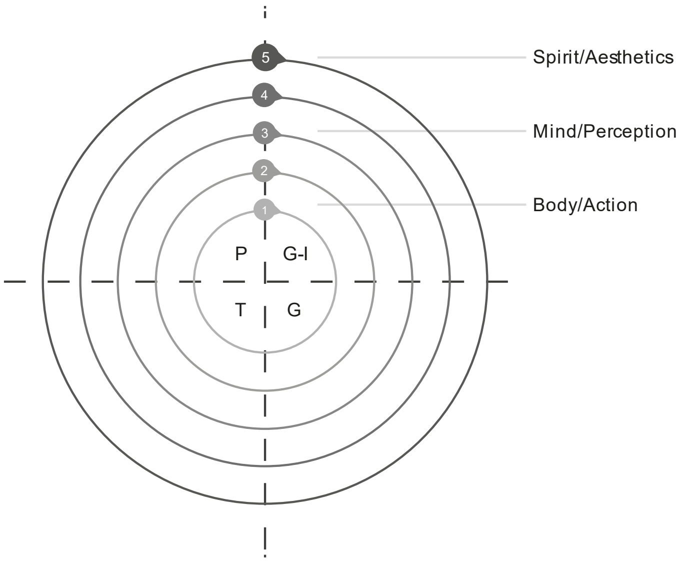


Figure 26. Basic structure of conceptual framework-model.

Table 11 provides examples of AUs found in BD curricular units. This AUs were custom designed for this purpose using the level of understanding and content topic matrices derived from a previous study (refer to Figures 17-18).

Table 11. Examples of possible AUs used in BD.

	Level 2	Level 3	Level 4	Level 5
Content topic A: Visual principles.	Enumerate the phases to obtain formal coherence.	Differentiate the classes of sameness.	Apply the gestalt laws in a composition.	Create a visual effect with formal coherence.
Content topic B: Colour.	Identify the saturated colours.	Explore mixing different hue.	Justify the use of a given colour scale.	Compose a colour contrast that suggests a specific emotion.
Content topic C: 3D principles of form creation.	Exercise the symmetry operation of a 3D module.	Explore different ways of structuring a volume.	Build up a 3D model.	Reflect on the sensations of entering a spheric space when compared to a cubic space.

The Figures 27-34 illustrate a possible situation encountered in a common BD lecture. Each coloured form (yellow triangle; blue circle; and red square) stand for different content topics. The coloured line that connects the same content topic enables the identification of how they are distributed along the learning activities during the lecture (see Figures 27-30).

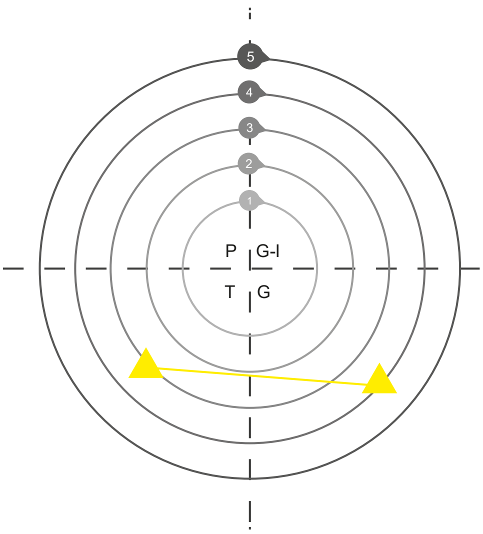


Figure 27. Content topic A (AUs: A4; A3)

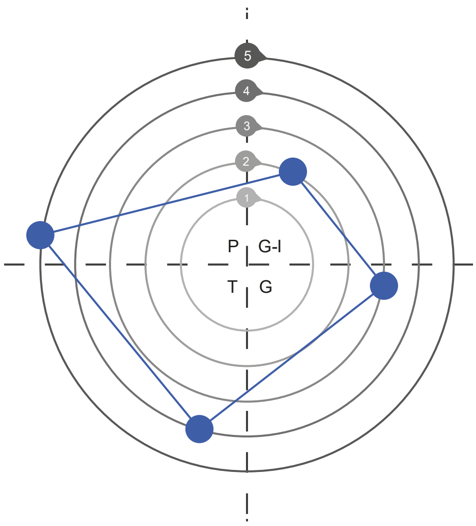


Figure 28. Content topic B (AUs: B2; B3; B4; B5).

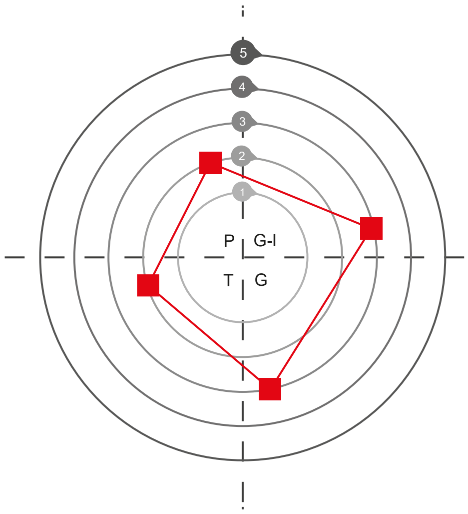


Figure 29. Content topic C (AUs: C3; C3; C2; C2).

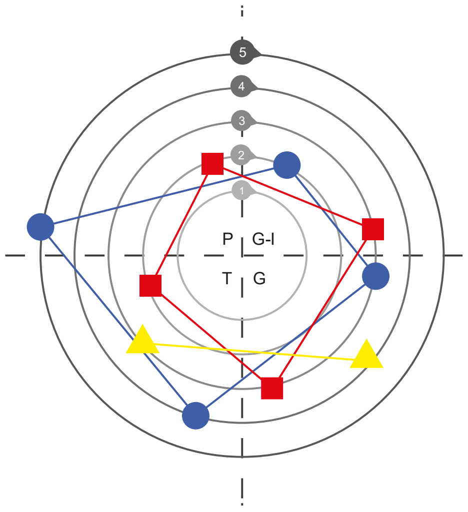


Figure 30. Distribution of the content topics A, B and C, by the four learning activities.

The first learning activity of the lecture relates to geometrical-intuitive field during which, the content topics B and C are being addressed using the verbs from the 2nd and 3rd levels of understanding, respectively (AUs: B2; C3) (see Figure 31). The activity that follows in the second quadrant (see Figure 32), relates to gestalt field, where the content topics A, B and C are being addressed using the verbs related to the 4th and 3rd levels of understanding (AUs: A4; B3; C3).

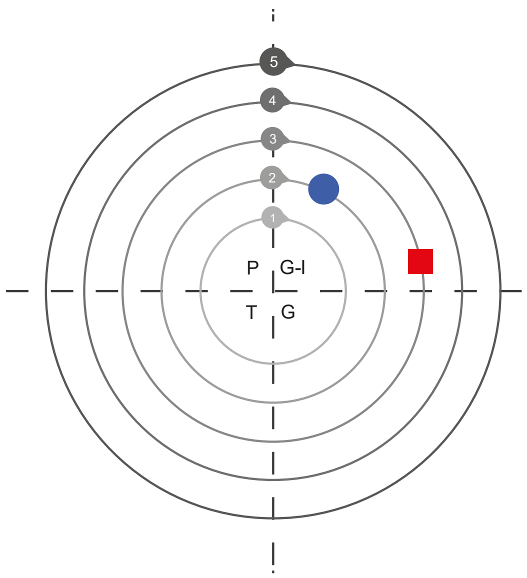


Figure 31. 1st learning activity: Geometric-Intuitive field (AUs: B2; C3);

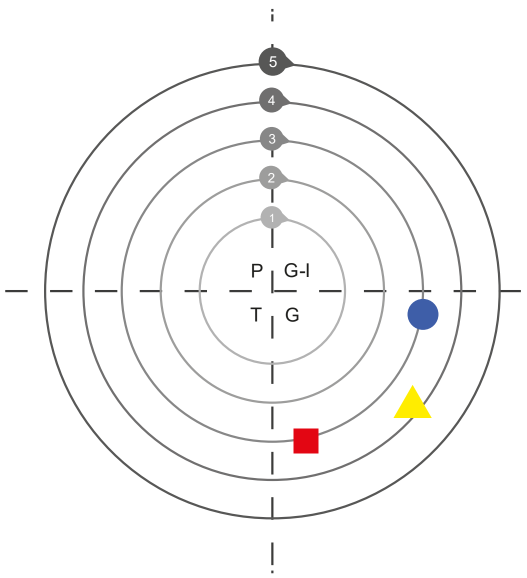


Figure 32. 2nd learning activity: Gestalt field (AUs: A4; B3; C3).

The next learning activity (Figure 33) addresses the topologic geometry, and the content topics A, B and C are required to be performed using, respectively, verbs from the 3rd, 4th and 2nd levels of understanding (AUs: A3; B4; C2). Finally, the phenomenological field requires that the content topics B and C are performed using the 5th and 2nd levels of understanding, respectively (AUs: B5; C2) (see Figure 34).

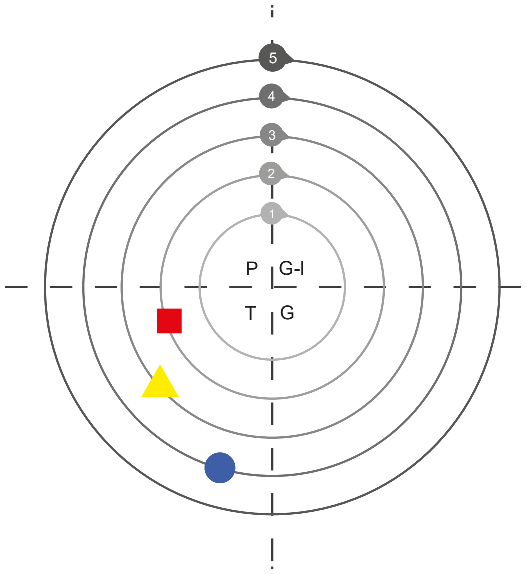


Figure 33. 3rd learning activity: Topologic field (AUs: A3; B4; C2);

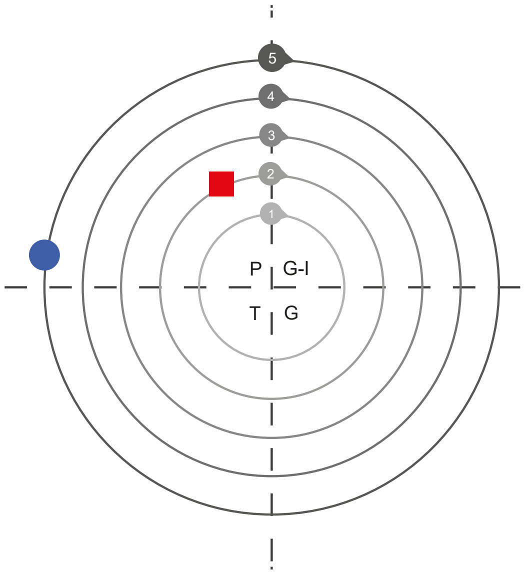


Figure 34. 4th learning activity: Phenomenological field: (B5; C2).

From the exposed, we think the mediation of philosophy and LOs can be possible and more accessible, aiming guiding the design of learning activities more capable of meeting the objectives of the curricular unit, the year programme and the whole study programme.

5.5. Discussion

Human dimensions encompassing body/actions; mind/perceptions; and spirit/aesthetics are present in all life experiences, with intricate interconnections and fluid boundaries. In the context of preparing the freshmen for creativity, a holistic approach is necessary, nurturing their physical, sensory, spiritual, and intellectual forces and capacities to work harmoniously (Itten, 1975, p. 9).

Individually, these dimensions can be elucidated as follows:

- Physical Dimension: The training of the body as an instrument of the mind (Itten, 1975, p. 9) can be cultivated through motor skills and repetitive tasks. These activities promote a personal understanding of object creation and materials interaction. Additionally, exploring various sensations and their articulation, (e. g., tactile, auditory, and visual), aligns with the body/action dimension.

- Perceptual Dimension: In BD activities, the perceptual dimension involves theoretical aspects related to geometric rules, perceptual organization principles (e.g., Gestalt laws), symmetry operations, and the physiology and phycology of colour and many other abstract concepts that require mental/perceptive activation. Marcolli's theory-methodology, in particular, focuses on perceptual development, facilitating systemic and complex observation and thinking.

- Spiritual and aesthetic dimension: The spiritual and aesthetic dimension highlights how higher perception or intuition, drive creativity. Methods like breathing and relaxation exercises, as seen in Itten's methodology, help release constrains on individual expression and foster genuine creativity. This could be achieved by exploring elements like colours, forms, textures, and their relationships, resulting in coherent aesthetic experiences. As aesthetics, intertwined with ethics, delve into values and judgment, BD pedagogy contributes to aesthetic education, offering a foundation for the development of moral judgments,[26] ethical decision-making and responsible design practices.

5.5.1. Addressing the challenges of design education at BD level

As mentioned earlier, the *Teoria del Campo* is structured according with four successive and cumulative fields: geometric-intuitive; gestalt; topologic and phenomenological (Marcolli, 1971). A similar structure has been advocate by Friedman and more recently reinforced by Meyer and Norman, (Friedman, 2019; Meyer & Norman, 2020, pp. 15–16) to address four cumulative groups of challenges that designers are facing, thus shaping the future of design education: performance, systemic, contextual and global.

In brief, the skills needed to tackle each level can be summarized as follow:

- To address performance challenges, traditional performance-based skillsets are crucial.
- For systemic challenges, the capacity for systems thinking is essential.
- Contextual challenges require the application of complexity and contextual skills.

[26] Alain Findeli, 'Ethics, Aesthetics, and Design', *Design Issues* 10, no.2 (1994): 66, https://doi.org/10.2307/1511628.

- Finally, global challenges demand proficiency in handling major complex sociotechnical systems (Meyer & Norman, 2020, pp. 15–19).

In the context of *Teoria del Campo* (Marcolli, 1971, p. 6) each field serves a distinct purpose:

- The geometric-intuitive field helps identifiyng the geometric physiognomy and properties of the materials, enabling the assignment of recognizable concepts to them.

- The gestalt field focus on how an object can be perceived differently according to a multiplicity of positions /points of view.

- The topological field emphasizes the object's relationship with individuals and other objects within its surroundings, creating an environment and a space where activities can take place.

- Finally, the phenomenological field broadens the perspective, considering the materials used, the design process, construction specifics and the interconnectedness of various parts to form a whole.

From our perspective, both the theoretical framework and model support the progression toward increased complexity, expanded perspectives, and greater responsibility. In this regard, this theoretical framework-model can aid in preparing the freshmen to develop the necessary skills for addressing complex sociotechnical systems.

5.5.2. Key ideas

Our ongoing quest to provide Basic Design activities that align with the demands of design education naturally led us to explore the roots of BD pedagogy. This exploration enabled us to develop the conceptual framework-model and draw insights into its potential implications. It became evident to us that BD pedagogy offers a viable solution to tackle certain challenges within design education. Subsequent discussions will delve further into this subject.

BD for the human demands

- Since the beginning of design education, BD was given a great importance. In fact, first-year university attendance represents a particularly critical period, as some students experience emotional and interpersonal problems (Almeida et al., 2003).

For most of them, it involves a transformation of personality that should be acknowledged by all HE participants. Furthermore, Davis draws our attention to the danger of the indiscriminate use of pedagogical styles (Davis, 2017, p. 62) as some approaches may be suitable for the more advanced students and detrimental for those beginning their studies. This is indicative that specificities must be taken to account by teachers and learning designers.

- It was clear for Itten and Moholy-Nagy that efforts should be invested in the elimination of fear and self-consciousness of freshmen students, considered obstacles for creativity, thus no judgments should be made in that learning phase (Moholy-Nagy, 1947b, p. 26). On the opposite, the climate of criticism, mistrust and high anxiety destroys the creative responses that require adventurousness and originality.
- Enthusiasm for discovering, accessing inner worlds and liberating freely inward forces, resonates with some characteristics of the infancy extended through adulthood, such as curiosity, interest, playfulness and tenderness. This human natural behaviour occurs due a biological phenomenon, neoteny (*Maturana Educar Es Amar*, 2017) that largely benefits learning life quality, in general.
- The unification of Artificial Intelligence (AI) and Intelligence Amplification (IA) (Frascara, 2020, p. 109) requires a whole person development to advance the adequate human capacity in resolving ethical dilemmas forced by AI. Accordingly, an unprecedented preponderance of the spiritual and philosophical dimensions is required towards an increasing need to “work out an individual plan of life, with self-analysis as its background” to a life evolved from within that values the being and not the profit (Moholy-Nagy, 1947a, p. 17).
- The reframing of the Socratic expression “Know thyself” in the present era requires to go beyond sharpening our introspection, but to understanding the functioning of the mind “in an attempt to use them in optimal accordance with our needs, goals, and desires” (Dehaene, 2020, p. 18). Design and learning thus supported by the neurosciences can enable purposeful action and thought required to thrive in the present learn-to-learn paradigm.
- It is worth stressing that self-knowledge, next to explanation, interpretation, application, perspective, empathy, are part of a criteria for identifying if a concept

is fully understood. These six dimensions appear overlapped and integrated, in a kind of six-sided view of a well learned concept (Wiggins & McTighe, 2005, p. 84).

- BD corresponds to the beginning of a two-folded lifelong learning path: learn to learn and learn to design. These two important competences can be potentiated by the articulation with Theory of Design Thinking (Burnette, 2009) thus linked to the neuroscience, for improving BD activities.

Supporting systems thinking

- For continuing supporting system thinking in present times, BD activities must move from predominant visual elements applied in tangible and material mediums, to other elements (e.g., auditory, tactile, olfactive, emotional) and intangible mediums. Such variety can help identify the whole system exhibited properties. To add the capacity of systemically apprehending a complex reality, Findeli reinforces the importance of training intuition, which could be provided by an aesthetical education, in BD (Findeli, 1994, pp. 63–64).
- Content topics specifically focused on the systemic thinking, such as formal coherence, layering, duality-unification, parts-whole, separation-connection, micro-macro scales, Gestalt laws, modularity, pattern creation, and many others, should be highlighted. The typical difficulties in recognizing those abstract principles in subsequent years and applying them in project can be surpassed by visual analogies and examples in different contexts, mediums and design areas. We think that an adequate alliance between digital technology mediums could contribute for understanding the abstract concepts.
- Nowadays, the use of Virtual Environments (VEs), allows immersive examples and new possibilities for exploring otherwise inaccessible spaces, times and phenomena. In this sense, a virtually promoted variety and multiplicity of experiences, could help freshmen to choose between specialties. It would thus align with Itten's original intention to help students finding their talents and interests for future careers.
- Applying the conceptual framework-model for renewing BD course
- The conceptual framework-model could assist in delivering new formats of the BD course, such as the Findeli's proposal of continuing BD through the entire design programme, in parallel with studio work (Findeli, 2001, p. 16). If defined in terms

of a basic set of LOs in its main components (i.e., levels of knowledge and content topics), BD can be distributed along several activities in different courses and year levels, during the entire undergraduate design program.

- Moreover, thus defined, BD can be also directed towards a tiered curriculum in design, (Meyer & Norman, 2020, p. 34) adaptable to a variety of geographic and socio-cultural conditions; for serving different objectives and requirements, whether defined by institutions, teachers, or by the students.
- Concomitantly, the framework-model can fit different option for curricula design, whether trajectories-based or positions-based curricula (Redström, 2020, p. 95) are considered, although the first can become more common due the prominence of individual choice and for being a way of responding to emerging needs in design (Redström, 2020, p. 95).
- The proposed conceptual framework-model provides the means to define and detail learning activities, as well as to monitor performance by teachers, pears, and students themselves. In this sense, it can assist self-learning and contribute for lifelong learning, essential also in design education (Meyer & Norman, 2020, p. 33).
- There has been a growing interest in VR-based tools for BD pedagogy. The rapid evolution of this technology enables the access by a wider public and applications in many areas. The highly valued sense of presence afforded by the integrative capacity of VR systems has shown probed benefits, particularly for learning purposes, making it a promising contribution to BD (Liu, 2020; Neves & Duarte, 2015b; Özgen et al., 2019). As we see it, VR could potentiate the BD activities that involve action-perception-aesthetics dimensions in articulation with the four levels of perceptive development.

5.6. Chapter Summary

Design education must evolve to equip designers the competences needed for designing complex socio-technical systems. Recent pandemic-related shifts towards digital learning have highlighted the need for adaptable teaching methods, shifting between presential and remote online classes. To address these challenges, we proposed a conceptual framework-model and its theoretical background. The framework-model is grounded on the BD original premises, emphasizing holistic human development (body-mind-spirit) and translating it into action-perception-aesthetics. We incorporate the theory-methodology of *Teoria del Campo*, to extend the potentialities of the framework-model to develop along the several activities the visual perception according to the four-level approach of Attilio Marcolli. The *Teoria del Campo's* visual perception approach fosters systemic thinking using geometry, also considering the logic of design (Nelson, n.d.; Nelson & Stolterman, 2012). Additionally, we have integrated Fernandes' model (recursive orders), aligning it with four cognitive levels (Constructive alignment theory) to achieve human potential in design education, as outlined by HE system requirements.

Our study unites BD's macro-scale pedagogic elements (theoretical-philosophical premises of BD) and Learning Outcomes components (i.e., the micro-scale elements), into a cohesive framework-model. It adds to the understanding of how BD pedagogy can leverage design education, in the present and future. It contributes for addressing design challenges and opportunities from a wider perspective, one that considers all the cognitive levels as playing a significative role in the learning process; and that by coherently combining them in learning activities, students can be afforded full awareness of their multidimensional human nature. It can therefore impact the capacity to empower human transformation in both internal and external, individual, and collective realms; and to balance inward and outward forces, practice and theory, action and reflection, humanity and technology, into a holistic way of being, in design and through design.

This study represents the possibility for the content topic to be addressed holistically and subsequently performed at the highest level of understanding. If consistently implemented in a long term (e.g., along the several years of a design study programme), such a coherence will more likely produce more consistent learning results. We suggest that the conceptual framework-model can be applied, with the due adaptations, to other lectures from the design undergraduate study programme and eventually, extended to other project areas.

The framework-model will undergo development and testing using a Human-Centered Design (HCD) approach. Students, teachers, and other stakeholders will collaboratively co-create and validate the tool before implementation, ensuring its effectiveness and practicality.

5.7. References

Almeida, L. S., Fernandes, E., Soares, A. P., Vasconcelos, R., & Freitas, A. C. (2003). Envolvimento académico: Confronto de expectativas e comporta- mentos em universitários do 1º ano. *Psicologia e Educação*, *II*(2), 14.

Anceschi, G. (2010). Design di base: Fondamenta del design. *Il Verri 'Newbasic'*, *43*. http://www.ilverri.it/index.php/la-rivista-del-verri/edizione-dal-1996/newbasic-detail

ANECA. (2004). *Bibro Blanco. Títulos de grado en Bellas Artes/Diseño/Restauración*.

Anita Rahardja & D. Rio Adiwijaya. (2011). Basic Design is Indeed for Expert. *Humaniora*, *2*(2), 925–931. https://doi.org/10.21512/humaniora.v2i2.3138

Bayirli, Ü. (2015). *Evaluation of Basic Design education at METU department of Industrial Design* [Master]. Graduate School of Natural and Applied Sciences of Middle East Technical University.

Besgen, A., Kuloglu, N., & Fathalizadehalemdari, S. (2015). Teaching/Learning Strategies Through Art: Art and Basic Design Education. *Procedia - Social and Behavioral Sciences*, *182*, 428–432. https://doi.org/10.1016/j.sbspro.2015.04.813

Biggs, J., & Tang, C. (2007). *Teaching For Quality Learning At University* (Edição: 3). Open University Press.

Bonsiepe, G. (1999). *Del Objeto a la Interfase*. Ediciones Infinito.

Bonsiepe, G. (2007). The Uneasy Relationship between Design and Design Research. In R. Michel (Ed.), *Design Research Now: Essays and Selected Papers* (pp. 25–39). Birkhäuser Architecture.

Bonsiepe, G. (2012). *Design como Prática de Projeto*. Edgard Blucher.

Boucharenc, C. (2006). Research on Basic Design Education: An International Survey. *International Journal of Technology and Design Education*, *16*(1), 1–30.

Burnette, C. H. (2009). *A Theory of Design Thinking*. https://www.academia.edu/209385/A_Theory_of_Design_Thinking

Colucci, K. (2011). What role will technology play in the future of design education. In *Icograda Design Education Manifesto 2011* (pp. 63–67). http://toolkit.icograda.org/database/rte/files/PR_IEN_Manifesto2011_webres.pdf

Cross, A. (1983). The educational background to the Bauhaus. *Design Studies*, *4*(1), 43–52. https://doi.org/10.1016/0142-694X(83)90007-8

Davis, M. (2017). *Teaching Design: A Guide to Curriculum and Pedagogy for College Design Faculty and Teachers Who Use Design in Their Classrooms*. Allworth.

Dehaene, S. (2020). *How We Learn: Why Brains Learn Better Than Any Machine . . . for Now*. Viking.

Dias, D. (2017). Learning Outcomes in European Higher Education. In P. Texeira & J. Shin (Eds.), *Encyclopedia of International Higher Education Systems and Institutions* (pp. 1–5). Springer Netherlands. https://doi.org/10.1007/978-94-017-9553-1_317-1

Federle, G. (2009). *Basic Design La formazione al design nella Scuola secondaria* [Doutoramento, Università Ca' Foscari Venezia]. http://dspace.unive.it/bitstream/handle/10579/1016/Tesi_Federle_2010.pdf?sequence=1

Fernandes, R. (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.* (http://eprints.ucm.es/12198/1/T32379.pdf). Universidade Complutense de Madrid.

Findeli, A. (1990). Moholy-Nagy's Design Pedagogy in Chicago (1937-46). *Design Issues*, *7*(1), 4–19. https://doi.org/10.2307/1511466

Findeli, A. (1994). Ethics, Aesthetics, and Design. *Design Issues*, *10*(2), 49–68. https://doi.org/10.2307/1511628

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

Frascara, J. (2020). Design Education, Training, and the Broad Picture: Eight Experts Respond to a Few Questions. *She Ji: The Journal of Design, Economics, and Innovation*, *6*(1), 106–117. https://doi.org/10.1016/j.sheji.2019.12.003

Friedman, K. (2019). *Design Education Today. Challenges, Opportunities, Failures*. https://www.academia.edu/40519668/Friedman._2019._Design_Education_Today_-_Challenges_Opportunities_Failures?email_work_card=view-paper

Gelmez, K., & Bagli, H. (2015). Learning from Students: Reflections from personal magazines in basic design course. *Design and Technology Education: An International Journal*, *20*(1). http://ojs.lboro.ac.uk/ojs/index.php/DATE/article/view/2019

Guerini, S. (2001). *Il Corpo Risponde. Le sinestesie nella didattica multimediale* [Licenciatura, Politecnico di Milano]. https://issuu.com/silviaguerini/docs/il_corpo_risponde_silvia_guerini_ca

Itten, J. (1975). *Design and Form: Basic Course at the Bauhaus* (Revised edition edition). Titles Supplied by John Wiley & Sons Australia.

Lerner, F. (2005). Foundations for Design Education: Continuing the Bauhaus Vorkurs Vision. *Studies in Art Education*, *46*(3), 211–226.

Liu, Y. (2020). Future Step of Basic Design: Between Synaesthesia Didactic and Virtual Learning. In F. Tosi, A. Serra, A. Brischetto, & E. Lacono (Eds.), *Design for Inclusion, Gamification and Learning Experience* (FrancoAngeli).

Liu, Y., Riccò, D., & Calabi, D. (2019). A synaesthetic learning approach to cave. *3rd International Conference on Environmental Design*, 273–280.

Marcolli, A. (1971). *Teoria del Campo—Corso di educazione alla visione* (1998th, 17ªed ed.). Sansoni Editore.

Marcolli, A. (1978). *Teoria del Campo 2—Corso di metodologia dalla visione* (1991st, 3ª ed. ed.). Sansoni Editore.

Maturana Educar es amar. (2017, August 2). https://www.youtube.com/watch?v=8bbO1vx-ILQ

Meyer, M. W., & Norman, D. (2020). Changing Design Education for the 21st Century. *She Ji: The Journal of Design, Economics, and Innovation*, *6*(1), 13–49. https://doi.org/10.1016/j.sheji.2019.12.002

Moholy-Nagy, L. (1947a). *The New Vision and Abstract of an Artist* (1928 Fourth revised Edition 1947 edition). George Wittenborn Inc.

Moholy-Nagy, L. (1947b). *Vision in Motion*. Wisconsin Cuneo Press.

Monache, S., & Rocchesso, D. (2014). Bauhaus Legacy in Research through Design: The Case of Basic Sonic Interaction Design. *International Journal of Design International Journal of Design [Online]*, *8*(3). http://www.ijdesign.org/ojs/index.php/IJDesign/article/view/1543/657#3

Munari, B. (1995). *Design e Comunicação Visual*. Edições 70.

Nelson, H. (n.d.). *Systemics—The Logics of Design*. Retrieved 18 April 2021, from https://www.academia.edu/11394542/Systemics_the_Logics_of_Design

Nelson, H. G., & Stolterman, E. (2012). *The Design Way: Intentional Change in an Unpredictable World : Foundations and Fundamentals of Design Competence*. Educational Technology.

Neves, A. G., Dias, D., & Duarte, E. (2018). As Basic Design promotes the Design Learning: Featuring the Portuguese Higher Education setting. *ICERI2018 Proceedings*, 7663–7671. https://doi.org/10.21125/iceri.2018.0376

Neves, A. G., Dias, D., Ramalho, J., & Duarte, E. (2019). Micro influence of Learning Outcomes in Basic Design. In E. Duarte & C. Rosa (Eds.), *Proceedings of the UNIDCOM 10th International Conference* (pp. 26–38). Edições IADE, Universidade Europeia.

Neves, A. G., & Duarte, E. (2015). Using Virtual Environments in Basic Design Education. In E. Duarte, C. Duarte, & F. Carvalho Rodrigues (Eds.), *Senses & Sensibility'15 Proceedings* (pp. 273–280). IADE - Creative University / Edições IADE.

Neves, A. G., Duarte, E., & Dias, D. (2018). Basic Design at IADE: Drawing the line. In E. Duarte (Ed.), *Design Doctoral Conference'18: TRANSgression. Proceedings of the DDC 5th Conference* (pp. 137–144). Edições IADE.

Neves, A. G., Duarte, E., & Dias, D. (2016). Basic Design meets Virtual Reality: A tentative methodology. *Design Doctoral Conference'16: TRANSversality. Proceedings of the DDC 3rd Conference*, 104–111. http://iade.us11.list-manage.com/track/click?u=bf2ccdc18181c0504e5a4099c&id=e01959960c&e=0698e9a4a1

Neves, A. G., Duarte, E., & Dias, D. (2017). The impact of a Virtual Reality-based tool on teaching and learning Basic Design: Early perceptions. In E. Duarte (Ed.), *Design Doctoral Conference'17: TRANScendency Proceedings of the DDC 4th Conference* (pp. 167–174). Edições IADE.

Neves, A. G., Niemeyer, L., Duarte, E., Dias, D., Ayanoglu, H., Teixeira, L., Saraiva, M., & Martins, F. (2016). Learning Basic Design with Virtual Reality: A methodological approach. *EDULEARN16 Proceedings*, 5394–5402. https://doi.org/10.21125/edulearn.2016.2283

Norman, D. A. (2016). When You Come to a Fork in the Road, Take It: The Future of Design*. *She Ji: The Journal of Design, Economics, and Innovation*, *2*(4), 343–348. https://doi.org/10.1016/j.sheji.2017.07.003

Obeid, S. (2019). *The Influence of Virtual Reality on Design Process Creativity in Basic Design Education* [Master]. Department of Interior Architecture and Environmental Design, İhsan Doğramacı Bilkent University.

OECD. (2012). *Assessment of Higher Education Learning Outcomes AHELO. Feasibility Study Report, vol 1 – Design and Implementation* (volume 1).

Özgen, D. S., Afacan, Y., & Sürer, E. (2019). Usability of virtual reality for basic design education: A comparative study with paper-based design. *International Journal of Technology and Design Education*. https://doi.org/10.1007/s10798-019-09554-0

Parashar, S. (2010). Basic Design Studio, an ongoing research. *Proceedings of the 2010 International Conference on Architectural Research The Place of Research/ The Research of Place*, 523–536. http://www.google.pt/url?sa=t&rct=j&q=innovation_in_design_education&source=web&cd=1&cad=rja&ved=0CCwQFjAA&url=http%3A%2F%2Fwww.allemandi.com%2Funiversity%2FInnovation_in_Design_Education.pdf&ei=er0MU4S6Ka3y7Abu94DABA&usg=AFQjCNHYtFt7J0ltBnv9q6XOx-5LTeCdyw&bvm=bv.61725948,d.bGQ

Redström, J. (2020). Certain Uncertainties and the Design of Design Education. *She Ji: The Journal of Design, Economics, and Innovation*, *6*(1), 83–100. https://doi.org/10.1016/j.sheji.2020.02.001

Riccò, D., Belluscio, A., & Guerini, S. (2003). Design for the synesthesia. Audio, visual and haptic correspondences experimentation. *Proceedings of the Senses and Sensibility in Technology –Linking Tradition to Innovation through Design*, 159–164.

Riccò, D., & Guerini, S. (2002). Synesthetic Design. The Laboratory of Basic Design as place of experimentation on the intersensory correspondences. *Proceedings of the 3rd Annual Meeting of the International Multisensory Research Forum. Geneva, Switzerland, May 2002*, 159–164.

Sausmarez, M. de. (1995). *Diseño básico: Dinámica de la forma visual en las artes plásticas*. Gustavo Gili.

Uysal, V. Ş., & Topaloğlu, F. (2017). Bridging the Gap: A Manual Primer into Design Computing in the Context of Basic Design Education. *International Journal of Art & Design Education*, *36*(1), 21–38. https://doi.org/10.1111/jade.12048

Wahl, D. C. (2016). *Designing Regenerative Cultures*. Triarchy Press Ltd.

Wick, R. (1993). *La pedagogía de la Bauhaus* (B. B. Álvarez, Trans.; Edición: edición). Alianza.

Wiggins, G., & McTighe, J. (2005). *Understanding By Design* (2nd Expanded edition). Assn. for Supervision & Curriculum Development.

Yaghan, M., & Ashour, R. (2008). The Battle of Grids: Preparing first year students for their upcoming design studies in Jordan. In *Designing Design Education Proceedings: Vol. Part II* (pp. 210–223). Designtrain Congress. http://www.elia-artschools.org/images/products/17/part_2.pdf

Chapter VI

> Technology is not the solution to human problems, because human problems belong to the emotional realm to the extent in which they are conflicts in our relational living that arise when we have desires that lead to contradictory actions. It is the type of human being, Homo sapiens amans, Homo sapiens aggressans or Homo sapiens arrogans, the moment we have access to a new technology, either as users or observers, which will determine how we use it or what we see in it.[27]
>
> Humberto Maturana

6. Anticipating the impact of Virtual Reality for learning the design fundamentals: Students' perceptions and perspectives

6.1. Abstract

The adoption of Immersive Virtual Reality (iVR) based solutions is on rise in Higher Education, and in design education, with some application on the teaching and learning of the design fundamentals, usually referred to as Basic Design (BD). While existing research explores the overall potential of iVR digital technology for developing new pedagogical tools, there is limited understanding of the students' expectations regarding its use. Such understanding is crucial in a Human-Centred Design (HCD) approach. This study's primary goal was to understand students' familiarity with and expectations regarding the use of iVR in BD education. An online questionnaire assessed the students' perception regarding: i) the challenges they face when learning design fundamentals; ii) the suitability of the digital

[27] A tecnologia não é a solução para os problemas humanos, porque os problemas humanos pertencem ao domínio emocional, na medida em que eles são conflitos em nosso viver relacional que surgem quando temos desejos que levam a ações contraditórias. É o tipo de ser humano, Homo sapiens amans, Homo sapiens aggressans ou Homo sapiens arrogans, no momento em que tivermos acesso a uma nova tecnologia, seja como usuários ou observadores, o que irá determinar como a utilizaremos ou o que veremos nela.

technology currently used; iii) their openness and expectations regarding the integration of iVR-based tools in the teaching-learning process. The results suggest that students perceive iVR-based tools as important and motivating aids for learning all the BD-related content topics. They expect iVR to assist in mastering the challenging content of 3D form. These findings are expected to support the development of iVR-based tools and iVR-assisted learning activities that align more closely with the expectations of future students, thereby fostering engaging teaching-learning experiences and improving learning outcomes.

6.2. Chapter Introduction

Virtual Reality has been progressively gaining significance in various educational contexts, offering undeniable advantages, even though its widespread adoption in education remains limited (Kavanagh et al., 2017). The level of immersiveness in a VR system plays a pivotal role in creating a sense of presence, defined as a convincing feeling of being fully immersed in the virtual world, momentarily disconnecting from the physical surroundings. This sense of presence can be a crucial factor for effective learning. It is the sought-after feeling in VR applications that fosters deep engagement with phenomena and, consequently, enhances the learning experience. Due to this fundamental aspect, immersive technologies are expected to gain even more importance and prominence in education (Dieck et al., 2021, p. vii).

In the realm of design education, digital technology plays a pivotal role in reshaping educational models and processes. VR is bound to become an integral part of this transformation, offering access to artificial reality through the production of new objects and environments (Colucci, 2011). Consequently, VR is poised to enhance the teaching-learning of the design fundamentals, specifically the Basic Design. Over the past decade, research has shown a growing interest in the impact of VR-based tools on Basic Design (BD) pedagogy, a trend likely to accelerate in response to the pandemic-related contingencies, as seen in general education settings (Ball et al., 2021). Furthermore, VR's innovative potential in the Higher Education context, positions the systematic adoption of VR technology as an increasingly plausible reality (Marks & Thomas, 2022).

The incorporation of VR -based tool to support teaching and learning within the realm of BD was approached by Neves & Duarte (2015). That theoretical exploration led us to a subsequent development and testing of a pedagogical tool in the context of a BD-derived course

(Neves, Niemeyer, et al., 2016). The non-conclusive results of that experimental study can be related with various contributing factors including the intricacy of coordinating pedagogical activities and experimental procedures, among others (Neves et al., 2017). Furthermore, the results also highlighted the quality of the experience of use. The experience was assessed by assessing emotional responses, indicating a high levels of students' satisfaction (Neves et al., 2017). Özgen et al., (2019) also examined the usability of VR during BD activities. Their findings support the idea that VR can significantly enhance the problem-solving activities in BD context, positioning it as a "promising and complementary tool in basic design education" (Özgen et al., 2019, p. 15). Another approach focused on innovative teaching in BD supported by the creation of synesthetic experiences using VR, offering holistic learning tools (Liu, 2020; Liu et al., 2019). VR's technology allowed an artificial combination of senses, potentially replacing or supplementing the natural sensory experience of the human body.

BD entails the teaching-learning of the design fundamentals, which are the "core concepts of the design approach that can be learned and improved on through practice and reflection" (Nelson & Stolterman, 2012, p. 4). Johannes Itten (1888-1967) introduced BD as part of the first design course, at the Bauhaus School of Design (1919-1933). Within Basic Design, design fundamentals, often referred to as content topics, encompass areas such as colour; 2D form; 3D form; texture; visual principles; personal values and skills; and materials and techniques. These fundamentals, combined with the levels of understanding, are the most significant building parts of the Learning Objectives (LOs). LOs hold particular significance in the Higher Education system, serving as indicators of the competences students are expected to attain (Dias, 2017). As such, they guide the focus of learning activities and provide a framework for assessing student performance.

In this sense, acknowledging students' expectations can offer valuable insights into potential limitations and factors contributing to the success of the the learning process and the attainment of the LOs (Baek et al., 2008). One effective means of uncovering user expectations is through questionnaires, as demonstrated by Bernardo and Duarte (2020). In their case, an online questionnaire revealed design teachers' familiarity with VR or Mixed Reality (MR), and their interest in learning and utilising VR for teaching purposes. However, research concerning students' expectations regarding the adoption of VR remains limited.

Consequently, this study aimed to assess students' openness/receptivity and expectations regarding the use of iVR for achieving the LOs in a near future, particularly in the context of learning the design fundamentals. The study collected the students' perception regarding: i) the perceived level of difficulty in learning various core design fundamentals; ii) the suitability of the digital technology employed in the learning process; iii) students' receptivity/expectations regarding the use of iVR-based tools during the teaching-learning process, as well as for achieving the main LOs.

Developing VR-based tools for BD learning, according to a Human-Centred Design (HCD) approach, requires involving the users throughout the design and development process, as mentioned in the normative ISO 9241-210 (International Organization of Standardization - ISO, 2019). Thus, to gather insights into students' expectations related to the potential use of such tools in the teaching-learning process, including LOs achievement, an online questionnaire was designed and administered.

6.3. Virtual Reality & Basic Design

As said before, in this study, design fundamentals align with the content topics, representing the "core concepts of the design approach that can be learned and improved on through practice and reflection" (Nelson & Stolterman, 2012, p. 4). These encompass the theory-practice aspects of design elements and their rules of composition. Design fundamentals include various subjects, including colour contrasts and harmonies; modularity and pattern creation; Gestalt laws; formal coherence; and others. Present versions of this course persist with different designations, such as Project in Basic Design; Form and Colour; Introduction to Design; Laboratory of Matter and Form (Neves, Dias, et al., 2018, p. 7668), just to name a few in the Portuguese HE context.

Colucci (2011) emphasizes the key role of technology in reshaping educational models and processes in design education. Virtual Reality will play an inevitable role as it enables access to artificial reality by creating synthetic objects and environments, which can closely resemble reality. Consequently, VR has the potential to enhance the teaching-learning of the design fundamentals, commonly referred to as BD. Over the past decade, research has increasingly highlighted the impact of VR-based tools on the BD pedagogy. Although this area of study is relatively recent and still scarce, it shows a growing trend. Given the challenges posed by the COVID-19 pandemic, the interest in VR is expected intensify further, as it provides a versatile digital medium capable of supporting both in-class and remote teaching-learning experiences.

Furthermore, the degree of immersion the VR system can offer, can significantly influence the sense of presence, defined as a convincing sense of being in the virtual world, indicating loss of consciousness that the body remains physically in the real world. Feeling presence can be an essential condition for effective learning. VR applications strive to engender this immersive experience, as it enhances engagement with phenomena and, consequently, facilitates learning. Due to these factors, immersive technologies like VR are anticipated to become increasingly prominent and essential (tom Dieck et al., 2021, p. vii).

Some studies have emphasized the necessity of restructuring the traditional approach to BD, which has historically relied predominantly on bodily natural competences, by including new digital technology. Uysal and Topaloğlu (2017) emphasised the the need to reconfigure BD's traditional philosophy of "learning by doing", which originates from a Bauhaus-oriented education, to align with the paradigm of digital technology. The incorporation of VR-based tools to support teaching and learning in BD courses has been explored in studies linking VR to BD. These studies have highlighted the potential of this alliance in creating innovative approaches to design education, with a focus on assisting students in achieving the learning outcomes and improving learning experiences (Neves & Duarte, 2015b, p. 273). Subsequent steps lead to the integration of a pedagogical tool in the context of a BD-derived course, specifically the 3D Design Laboratory, at IADE Design School. The development of the VR-based tool aimed to address some of the challenges faced by first-year students, such as low engagement in the manual tasks and the poor emotional connection with the abstract structures (Neves, Niemeyer, et al., 2016, p. 5400). Employing a quasi-experimental methodology, the study revealed the need for constant support from the computer graphics and computer sciences technicians. Additionally, it noted limited interactions from the students, partly due to the constrains of using a mouse and a keyboard that restricted the natural movements, and the limited time each student had to interact with the virtual tool. Furthermore, students' proficiency in 3D computer graphics and digital modelling software, necessary for creating the required forms, was reported as lacking. The results of the experimental study (Neves et al., 2017, p. 117) show no significant differences between the groups (with and without VR). This outcome can be attributed to the complexity of the task, which involved coordinating pedagogical activities and experimental procedures. Nevertheless, the study also included an analysis of video recorded sessions, which indicate the quality of the user experience through emotional reactions detection. It was reported that "all students showed some level of satisfaction during the session”, ranging from pleasant surprise, amusement and fascination (Neves et al., 2017, p. 117).

Recently, there has been a notable emphasis on exploring the practical applications of VR in design education, particularly within basic design instruction. Research findings on VR tools usability have consistently highlighted the potential of VR to significantly enhance problem-solving skills among interior architecture and architecture students, positioning it as a promising and valuable tool for basic design education (Özgen et al., 2019). Furthermore, investigations have delved into how VR influences creativity within the design process in basic design education, primarily by comparing immersive and non-immersive virtual design environments (Obeid, 2019). The results have shown that the immersive environment fosters a deeper sense of involvement in the design process, heightened motivation, and an enhanced state of flow, ultimately leading to greater creativity compared to the non-immersive counterpart. Moreover, the immersive environment promotes bodily involvement, further fueling participants' creativity during the design process. In addition to these findings, innovative approaches to teaching basic design have explored the potential of VR to create synesthetic experiences, providing comprehensive tools for learning (Liu, 2020; Liu et al., 2019). Through VR, it becomes possible to artfully blend and augment sensory perceptions, effectively enhancing the learning experience beyond the constraints of the natural human senses.

6.3.1. Virtual Reality-based tools for achieving the learning outcomes

In higher education, just like in any other teaching-learning context, the primary aim of BD learning activities is to provide design students with engaging experiences that facilitate the achievement of LOs by the end of a learning cycle, thereby ensuring effective learning.

LOs, also referred to as academic goals, expected results, or learning objectives, encompass a wide range of knowledge, skills, competences, values, beliefs, and attitudes, that the students are expected to attain (Dias, 2017). These LOs are pivotal in guiding the design of learning activities, ensuring that they align with the intended outcomes. This alignment, as proposed by the constructive alignment theory (Biggs & Tang, 2007), involves specifying the cognitive levels of performance that students should achieve in a certain content topic by using appropriate verb in the LOs. The structure of the observed learning outcome - SOLO taxonomy offers a list of appropriate verbs in two main categories: the low levels of understanding and high levels. A prestructural level precedes four other levels and it stands for no existing competence, for which is absent from the SOLO table of verbs. The low-level outcomes involve simple and quantifiable verbs, as in the unistructural level and the multistructural level. High-level outcomes include relational level and extended abstract level.

A synchronic analysis to the Portuguese BD courses used the constructive alignment theoretical model for identifying the two main components of LOs (i.e., levels of understanding and content topics) present in that context (Neves, Dias, et al., 2018; Neves, Dias, Duarte, et al., 2019; Neves, Dias, Ramalho, et al., 2019). For this specific study, we considered the verbs and content topics that resulted from the previous analysis, as it will be further advanced.

Given the significance of LOs, educators and learning designers should judiciously incorporate digital technologies like VR into the development of appropriate learning activities, ensuring a harmonious alignment between technology, pedagogy, and the intended learning outcomes.

6.4. Method

Developing VR-based tools for BD learning, following a Human-Centred Design (HCD) approach, requires active involvement of users throughout design and development phases, as mentioned in the normative ISO 9241-210 (International Organization of Standardization - ISO, 2019). Unfortunately, due to various constraints, explained above (e.g., lack of authorisation to conduct the experiment within the classroom context, constraints imposed by the pandemic) this approach could not be fully explored, as was the initial intention, and ended up not containing as many iterations as would have been necessary. However, we wanted, as far as possible, to assess the opinion of potential users of this technology and, to this end, we developed a questionnaire that allowed us to access the expectations of the students towards the possible use of such tools in the teaching-learning process, including, for performing the LOs.

6.4.1. Participants

A total of 58 students, 18 males (31%) and 40 females (69%), with age ranging from 19 to 28 (M=20,45; SD=1,547), answered an online survey (See Table 12 for Age and Table 13 for gender).

Table 12. Age of the participants.

	N	Minimum	Maximum	Mean	Std. Deviation
Age_1.1	58	19	28	20,45	1,547
Valid N (listwise)	58				

Table 13. Gender of the participants.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	male	18	31,0	31,0	31,0
	female	40	69,0	69,0	100,0
	Total	58	100,0	100,0	

The participants were currently enrolled in design bachelor's degrees in Portugal and in Turkey, being 51 participants from a Portuguese institute, IADE, Universidade Europeia, and 7 participants from Turkish institutions, namely, 1 from Middle East Technical University; and 6 from Atilim University Fine Arts, Design and Architecture Faculty (see Table 14). In the Figure 35 is shown the attended undergraduate design degrees of the participants: Design (49 participants); Design Global (2 participants); Fashion and Textile Design (5 participants); and Industrial Design (2 participants).

All the participants had already completed at least one course that specifically addressed the design fundamentals, since the academic year of 2017-18.

Table 14. Origin of the lecture for learning the design fundamentals: undergraduate design degree; HE institution; and country.

		Name of the Higher Education institution_3			
		Middle East Technical University, Turkey	Atilim University Fine Arts, Design and Architecture Faculty, Turkey	IADE - Faculdade de Design, Tecnologia e Comunicação, Portugal	Total
Name of the undergraduate design degree_2	Design	0	0	49	49
	Design Global	0	0	2	2
	Fashion and textile design	0	5	0	5
	Industrial design	1	1	0	2
Total		1	6	51	58

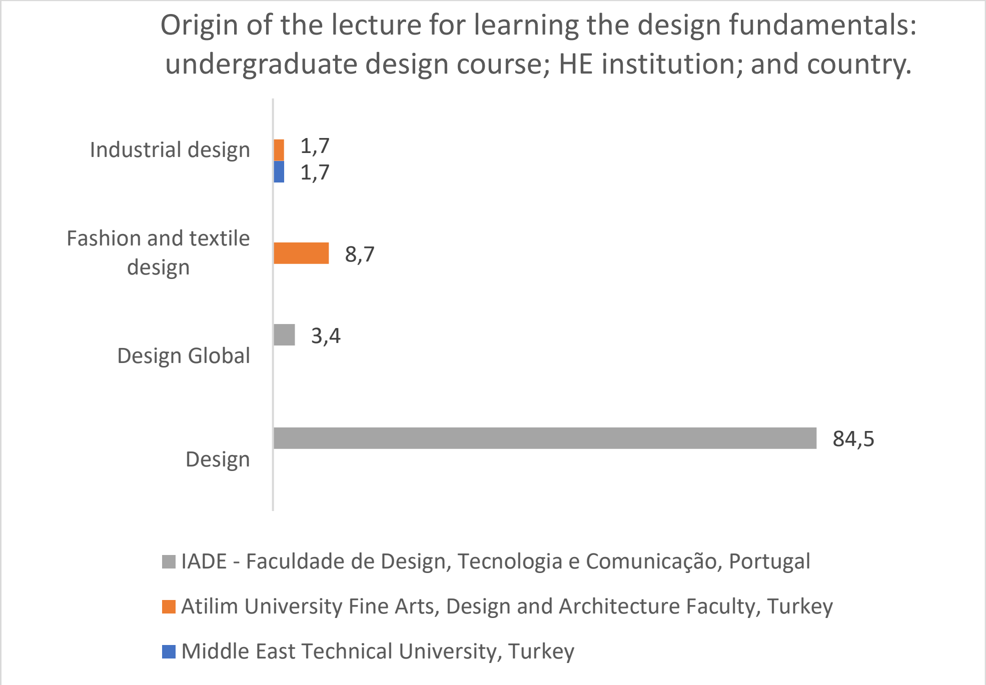


Figure 35. Origin of the lecture for learning the design fundamentals: undergraduate design degree; HE institution; and country (%).

6.4.2. Procedure

An online questionnaire was created using a free online form builder, JotForm, subsequently disseminated using the link: https://form.jotform.com/211013320144332.

In the first part of the questionnaire, the objectives of the study were presented to the participants, who agreed to participate and signed an informed consent, thus enabling the next sections of the questionnaire. The collected data was analysed using IBM SPSS statistics for Windows, v. 27 (IBM Corp., 2020). A descriptive statistics was applied according to Marôco (2021).

6.4.3. Materials

Online questionnaire

The online questionnaire was divided into two parts.

In the first part, we gathered students' perceptions regarding their previous experiences with BD courses, focusing on specific content topics identified in prior research by Neves et al. (2019). These content topics included Design fundamentals, which encompass subcategories like Colour, 2D form, 3D form and visual principles, as well as Personal values and skills, Means and Techniques, and Texture.

The second part involved students watching a brief video introducing iVR technology. Following this, we collected data on their familiarity with iVR, their receptivity to it, and their expectations regarding the use of iVR-based tools for teaching-learning the design fundamentals, including for performing some LOs that are characteristic of the BD context.

Table 15 presents some examples of the content topics applied. The content topic Texture was used for two reasons: first, to verify whether it should be included in current Design study programs, as suggested by prior research (Neves, Duarte, et al., 2018); second, to gain insight into how students perceive the learning of this content topic when utilizing iVR.

Table 15. Content topics used in BD.

Colour (e.g., chromatic contrasts and harmonies; theory of colour; symbology of colour)
2D principles of form creation (e.g., modularity-patterning; laws of Gestalt; formal coherence; lettering; point-line-plane)
3D principles of form creation (e.g., solids; structures; length-width-height; modularity-patterning; formal coherence)
Personal values and skills (e.g., autonomy; self-knowledge; collaboration; communication; resilience; curiosity; confidence)
Materials and techniques (e.g., paper; cardboard; wood; ceramics; cutting; folding; printing)
Texture (e.g., tactile boards; visual textures; surface of objects)
Visual (perceptive) principles (e.g., parts-totality; macro-micro; figure-ground; layering; scale; proportions)

The online questionnaire also included the Taxonomy of Digital Technology in education, from Zednik (Zednik, 2020; Zednik et al., 2014) for assessing the use of digital technology during the BD lectures. The taxonomy includes:

- Authoring tools: for creation of content and information; communication and collaboration; learning assessment.
- Search, store and socialize content tools: for finding, saving and sharing information and content, in a diversity of digital formats.

- Virtual immersive tools: for experiences very similar to the real environment, for immersion in a virtual world.
- Assistive technologies: for the participation and access of people with disabilities to information and content, allowing more autonomy, learning and digital inclusion.
- Task management tools: for administration, organization and systematization of daily tasks, professional projects.

Before answering the questions related to the use of iVR, some examples of iVR digital technology were presented to the participants in a four-minute video (see Figure 36). The video was created in Adobe Premiere software using parts of promotional videos available on the internet. The video was embedded in the questionnaire and watched in the link: https://youtu.be/W7xwk_ny9FM.

Figure 36. Cover of the video presenting iVR-based tools.

The LOs employed in the questionnaire were drawn from previous studies that identified the LOs within the context of BD study plans Portugal (Neves, Dias, et al., 2018; Neves, Dias, Duarte, et al., 2019; Neves, Dias, Ramalho, et al., 2019). These LOs consist of two main components: content topics, as previously presented in Table 15, and levels of understanding, which refer to verbs/actions to be performed by the student relating the content topics. The levels of understanding used in this questionnaire (see Table 16), resulted from the list of verbs identified in the matrix of the levels of understanding (see Figure 17, in this document). Within this matrix, we chose the four most frequently occurring verbs for each level of understanding.

These verbs were then paired with the aforementioned content topics to create examples (e.g., related to Colour: If I use an iVR-based tool I can represent an achromatic scale). This approach provided respondents with a choice of one example per level of understanding, resulting in a total of four options for each content topic.

Table 16. Levels of understanding (Verbs/actions) used in BD.

2nd level	**3rd level**	**4th level**	**5th level**
Identify	Acquire habits/practice	Analyze	Reflect/contemplate
Represent	Differentiate	Integrate	Substantiate/prove
Exercise	Present results	Criticize/judge/decide	To master
Recognize	Explore/Experiment	Apply	Create/compose

6.5. Results

The questionnaire results initially centre on students' perceptions of their past learning experiences related to the design fundamentals. Subsequently, the questionnaire explores their expectations regarding the use of iVR-based tools in the teaching-learning process, which includes performing the LOs present in the BD pedagogy.

6.5.1. Learning the design fundamentals

The perception of previous learning experiences relating the design fundamentals was measured in the first moment it occurred for the participants, despite the semester (i.e., the 1st, 2nd and so on) and independently of the number of semesters. The perceived relevance of the lecture was assessed using a Likert type scale, from 1 to 5, in which 1 meant "Little relevant" and 5, "Very relevant" (see Table 17 and Figure 37).

Table 17. Frequencies statistic: Perceived relevance of the lecture.

N	Valid	58
	Missing	0
Mean		3,10
Std. Error of Mean		,163
Median		3,00
Mode		2
Std. Deviation		1,238
Variance		1,533
Range		4
Minimum		1
Maximum		5
Sum		180

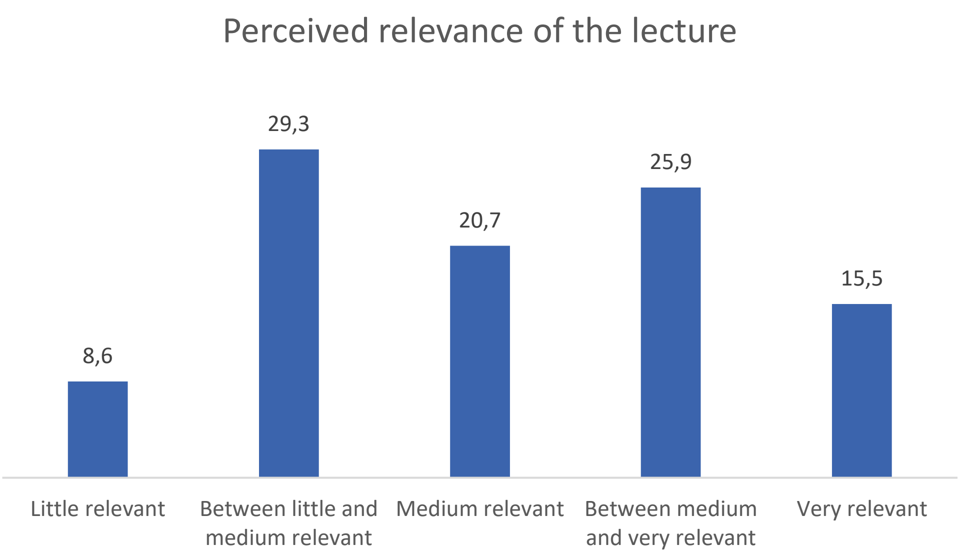


Figure 37. Perceived relevance of the lecture (%).

Regarding the perception of easiness to learn the content topics, participants replied using a Likert type scale, from 1 to 4, indicative of “Not easy at all” and “Very easy”, respectively. Results show that Colour is the easiest to learn, followed by Personal values and skills. Down the list, the content topic considered the most difficult to learn is 3D form (see Table 18 and Figures 38-39).

Table 18. Perceived ease to learn the content topics.

		Colour_7.1	2D principles of form creation_7.2	3D principles of form creation_7.3	Personal values and skills_7.4	Materials and techniques_7.5	Texture_7.6	Visual principles_7.7
N	Valid	58	58	57	58	55	48	56
	Missing	0	0	1	0	3	10	2
Mean		3,12	2,76	2,53	2,83	2,62	2,56	2,79
Median		3,00	3,00	2,00	3,00	3,00	2,50	3,00
Mode		3	3	2	3	2	2	3
Std. Deviation		,880	,757	1,020	,819	,972	,897	,909
Variance		,775	,572	1,039	,672	,944	,805	,826
Range		3	3	3	3	3	3	3

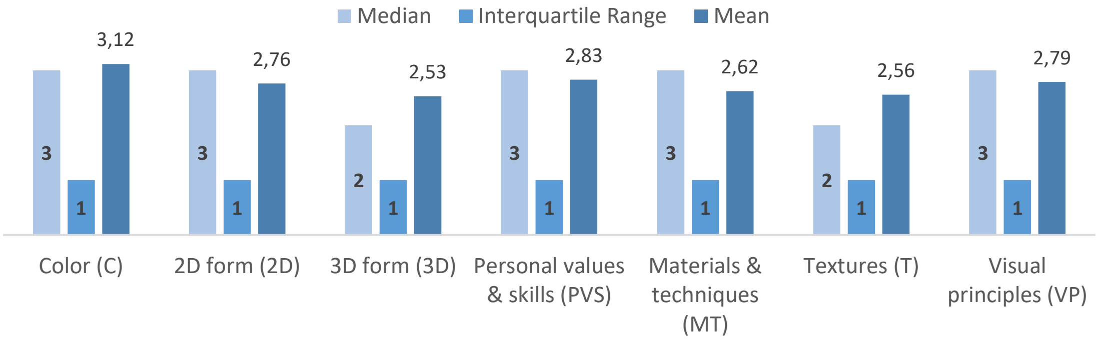


Figure 38. Perceived ease to learn the content topics.

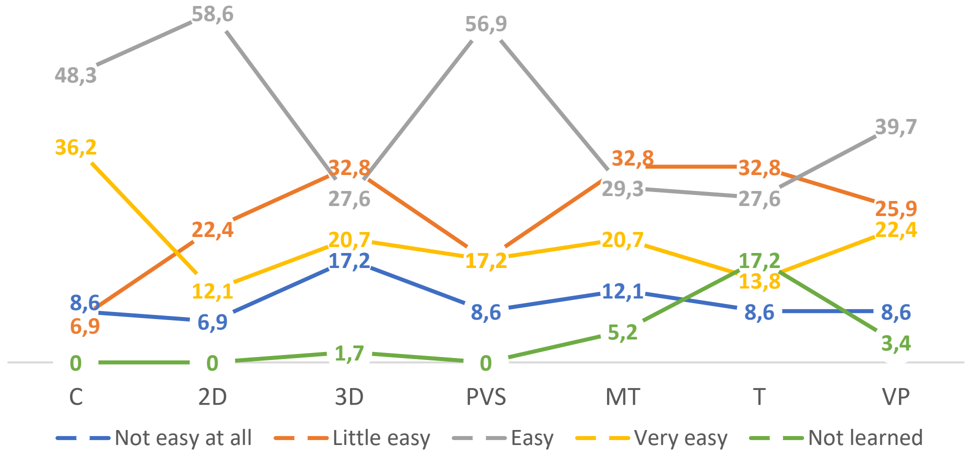


Figure 39. Perceived ease to learn the content topics (%).

Relating the use of digital technology in the BD teaching-learning context, participants were asked to reply using a Likert type scale, from 1 to 5, meaning "Never used" to "Regularly used", respectively, different types of technology. As reported, Virtual immersive tools are the least used, much as Assistive technologies. Task management tools were indicated as often used, surpassed by the Search, store and socialize, and by Authoring tools, both acknowledged as being regularly used (see Table 19; Figure 35).

Table 19. Digital technology: frequency of use.

		Authoring tools_8.1.1	Search, store and socialize content tools _8.2.1	Virtual immersive tools_8.3.1	Assistive technologies_ 8.4.1	Task management tools_8.5.1
	Valid	58	58	58	58	58
	Missing	0	0	0	0	0
Mean		4,26	4,21	2,48	2,47	3,48
Median		5,00	5,00	2,00	2,00	4,00
Mode		5	5	1[a]	1	4
Std. Deviation		,983	1,005	1,341	1,489	1,260

a. Multiple modes exist. The smallest value is shown

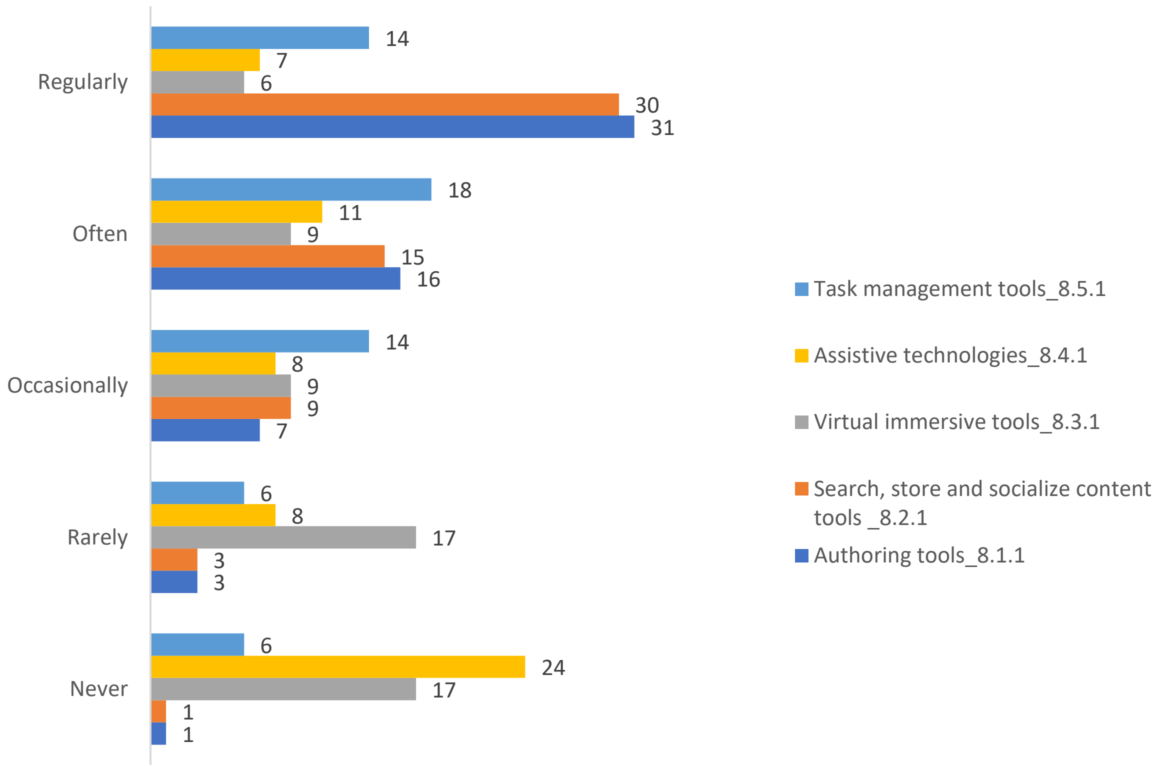


Figure 40. Digital technology: frequency of use (%).

As for the adequacy of use, was assessed the relation between the perceived adequacy of use and the perceived ideal of use, as both use the same Likert type scale, from 1 to 5, meaning “Never used” to “Regularly used” (i.e., the second was subtracted from the first). A scale from 1 to 9 was identified, representing 1, an extreme lack of use; and 9, an extreme excess of use. In the middle, 5 indicates adequacy of use whenever the level of use and the ideal of use are the same (e.g., level of use 3 and ideal of use, also 3).

In general, the use of digital technology is considered adequate in all the categories, although less adequacy was perceived related to Virtual immersive tools and Assistive technologies, indicating that these technologies should be more used (Table 21 and Figure 41-43).

Table 20. Digital technology: adequacy of use.

		Authoring tools_8.1.4	Search, store and socialize content tools_8.2.4	Virtual immersive tools_8.3.4	Assistive technologies_ 8.4.4	Task management tools_8.5.4
N	Valid	58	58	58	58	58
	Missing	0	0	0	0	0
Mean		4,83	4,91	4,02	3,69	4,40
Std. Error of Mean		,102	,116	,160	,231	,149
Median		5,00	5,00	4,00	5,00	5,00
Mode		5	5	5	5	5
Std. Deviation		,775	,884	1,221	1,759	1,138
Variance		,601	,782	1,491	3,095	1,296
Range		4	5	5	5	5
Minimum		3	3	1	1	1
Maximum		7	8	6	6	6
Sum		280	285	233	214	255

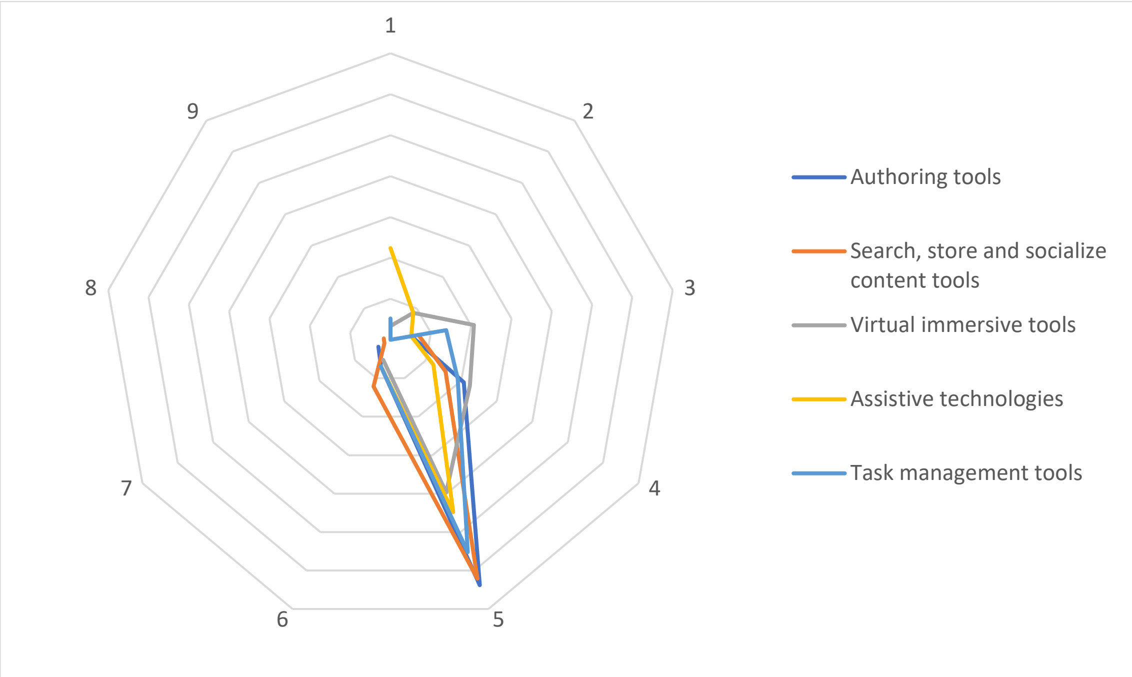


Figure 41. Digital technology: adequacy of use (%).

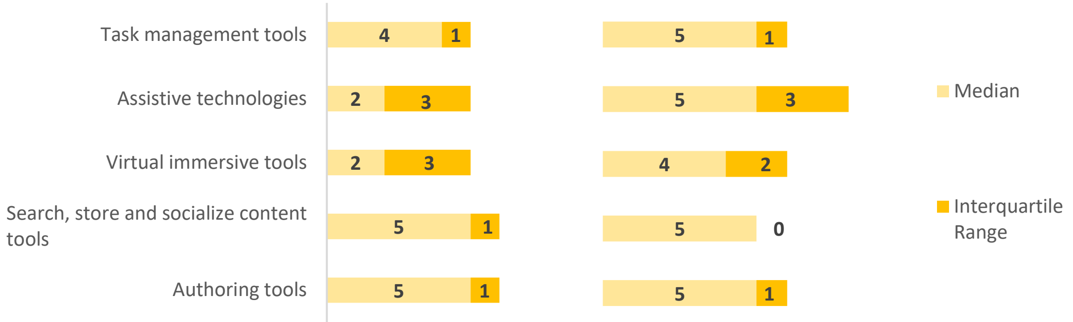


Figure 42-43. Use of digital technology (left) & Adequacy of digital technology (right).

6.5.2. Expectations to use iVR-based tools

Familiarity with iVR

Table 21. Proficiency with iVR.

	Valid	58
	Missing	0
Mean		2,52
Median		3,00
Mode		3
Std. Deviation		1,047
Range		3

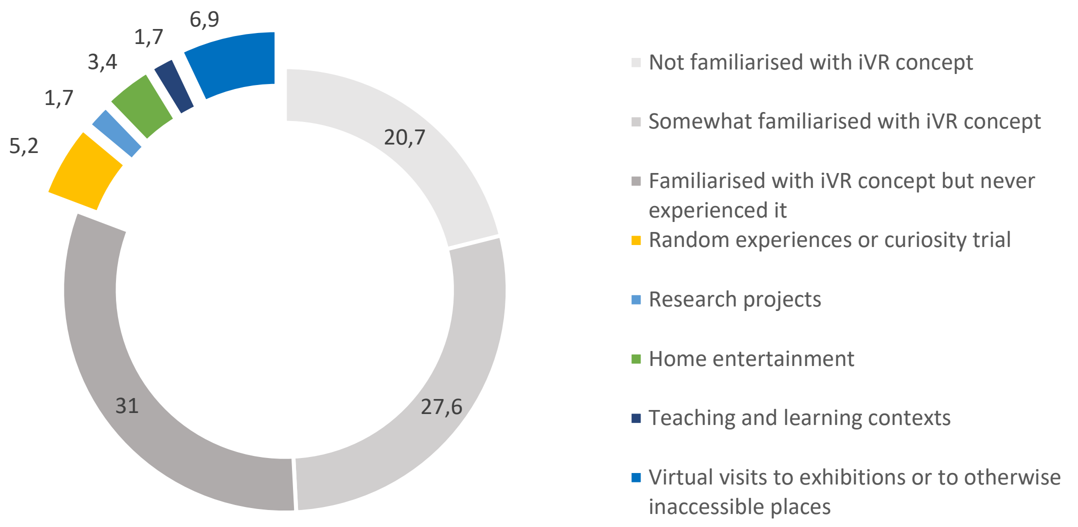


Figure 44. Proficiency with iVR (%).

Students' proficiency in VR technology was assessed, thus revealing that 79,3% do not have any experience with VR. The remaining 20,7% had at least one experience with the digital technology, more accentuated in the Teaching-learning contexts (6,9%) followed by Random experiences or curiosity trials (5,2%) (see Figure 44).

Immersive Virtual Reality for teaching-learning the design fundamentals

An important aspect that was assessed in the questionnaire was the perception of the students towards the impact of iVR-based tools to the different aspects of the teaching-learning process. The students classified some affirmations using a scale from 1 to 4, in which 1 stood for not agree; 2 for slightly agree; 3 for agree; and 4 stood for strongly agree. They all agreed that the iVR-based tools affect positively all the referred aspects (Tables 22-23; and Figure 45) such as:

- Contributing to attaining the objectives of the lecture
- Enable more focus and concentration during the tasks
- Allow collaboration
- Support remotely (asynchronous and synchronous) activities
- Favour presential/in-class activities
- Support real-time assessment
- Favour student-teacher interactions
- Support self-learning and self-Knowledge

Table 22. Perception of using iVR for the teaching-learning of the design fundamentals – 1 to 6.

		motivate students to the lecture_11.1	attaining the objectives of the lecture_11.2	focus and concentration _11.3	collaborative tasks_11.4	remote activities_11.5	presential / in-class activities_11.6
N	Valid	58	58	58	58	58	58
	Missing	0	0	0	0	0	0
Mean		3,47	3,12	3,09	3,24	3,14	3,24
Std. Error of Mean		,079	,082	,113	,083	,080	,102
Median		4,00	3,00	3,00	3,00	3,00	3,00
Mode		4	3	4	3	3	3
Std. Deviation		,599	,623	,864	,630	,605	,779
Variance		,358	,389	,747	,397	,367	,607
Range		2	2	3	3	2	3
Minimum		2	2	1	1	2	1
Maximum		4	4	4	4	4	4
Sum		201	181	179	188	182	188

Table 23. Perception of using iVR for the teaching-learning of the design fundamentals – 7 to 12.

		real time assessment _11.7	student-teacher interaction _11.8	creativity_11.9	self-learning and self-knowledge _11.10	simulations of authentic real-life contexts_11.11	exploring different perceptive senses_11.12
N	Valid	58	58	58	58	58	58
	Missing	0	0	0	0	0	0
Mean		3,21	3,09	3,59	3,26	3,43	3,43
Std. Error of Mean		,104	,113	,089	,100	,086	,102
Median		3,00	3,00	4,00	3,00	3,50	4,00
Mode		3	3	4	3	4	4
Std. Deviation		,789	,864	,676	,762	,652	,775
Variance		,623	,747	,457	,581	,425	,600
Range		3	3	3	3	3	3
Minimum		1	1	1	1	1	1
Maximum		4	4	4	4	4	4
Sum		186	179	208	189	199	199

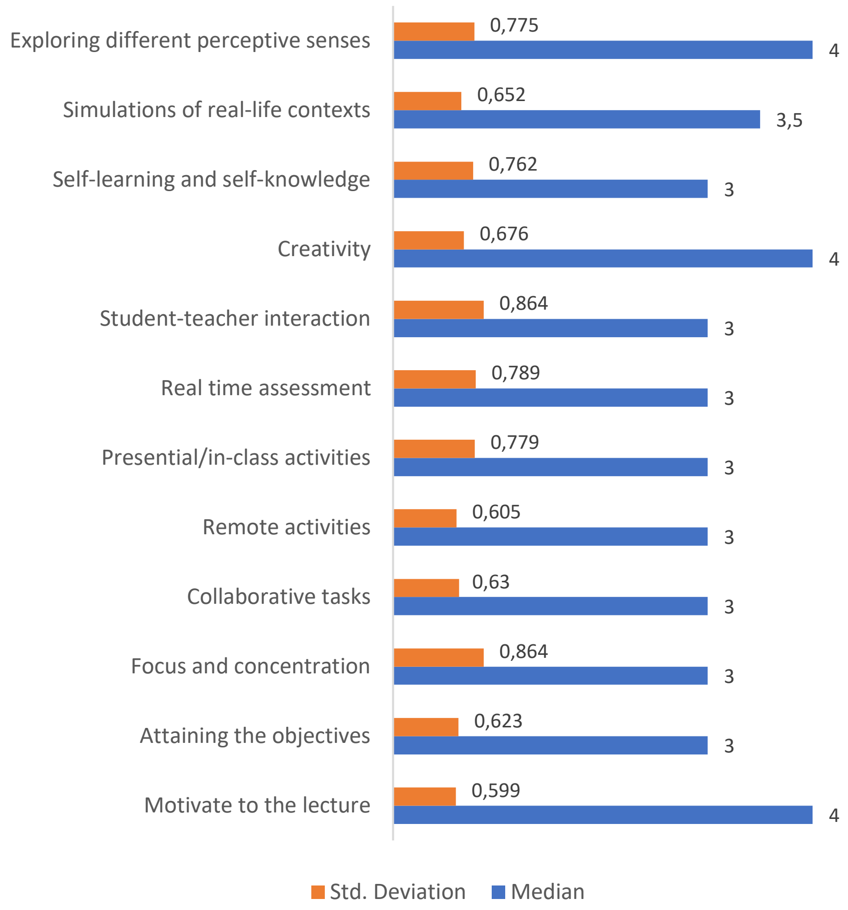


Figure 45. Perception of using iVR for the teaching-learning of the design fundamentals (%).

Nevertheless, a higher contribution is expected for motivating students to the lecture; for creativity to flourish; for exploring different perceptive senses; and for simulations of authentic real-life contexts.

Immersive Virtual Reality-based tools to perform the LOs

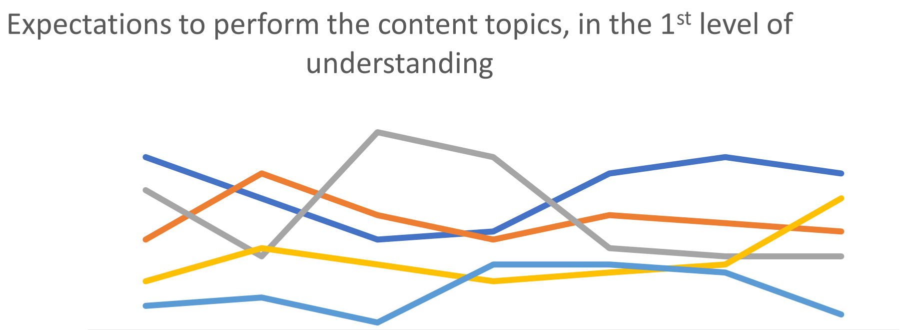
The questionnaire assessed the expectations to use iVR-based tools to perform the Los. The LOs were presented per level of understanding, using the verbs from Table 15, in combination with the content topics pointed in Table 14. In each level of understanding, the participants could also opt for None. The selection of this option can be indicative of two conditions: that none of the presented options were expected but a different action could have been indicated, if offered the possibility; or that iVR-based tools are not expected to be used for performing LOs at that level, at all. To enable the distinction, it would require extending an already long questionnaire by including one more option in the available answers, and by that fact, it was not added. However, possible opportunities to apply the questionnaire may clarify the reason for selecting None and identify other possible verbs and consequently, different LOs.

As observed in figures 32-35, there is a high level of expectations to use iVR-based tools to perform all the LOs, being least expected the verbs from the 4th level (91,6%), immediately followed by the 1st and 3rd levels (91,8%). Finally, the verbs from the 2nd level of understanding are the ones perceived as more adequate to be performed using iVR-based tools, with 93,3% of the participants agreeing with their use.

The most frequent verb in each level of understanding, presented in ascending order indicate that Apply is the most frequent in the 3rd level (27,1%); Identify, in the 1st level (29,3%); Explore/experiment in the 2nd level (32%); and Create/compose, in the 4th level (37%), is the one that presents the higher preference of all. Accordingly, these are the verbs that are offered to be considered in future iVR-based tools for BD.

The expectations to perform the verbs proposed at each level are indicative of which LOs might have more acceptance, and therefore, produce better learning results among students.

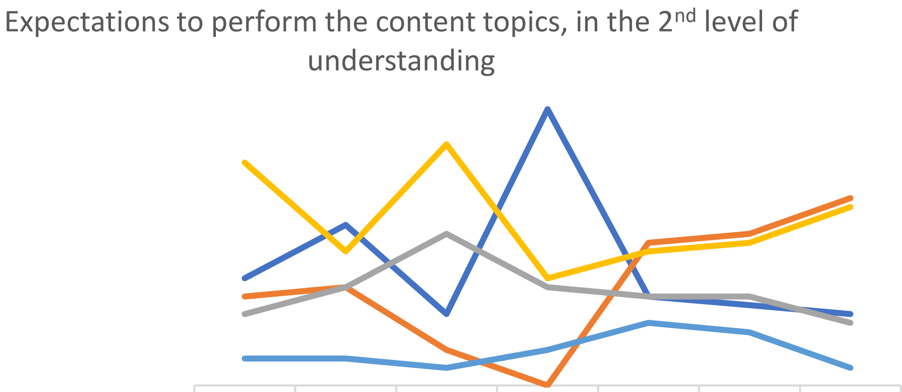
In the 1st level of understanding, the verb Recognize has 15% of the preferences, followed by Represent, with 23,15%, Exercise, with 24,37%, and Identify, which gathered the preference of 29,3% of the participants (see Figure 46).



	C	2D	3D	PVS	MT	T	VP
Identify	36,2	27,6	19	20,7	32,8	36,2	32,8
Represent	19	32,8	24,1	19	24,1	22,4	20,7
Exercise	29,3	15,5	41,4	36,2	17,2	15,5	15,5
Recognize	10,3	17,2	13,8	10,3	12,1	13,8	27,6
None	5,2	6,9	1,7	13,8	13,8	12,1	3,4

Figure 46. Expectations to perform the LOs, in the 1st level of understanding, using IVR-based tools (%).

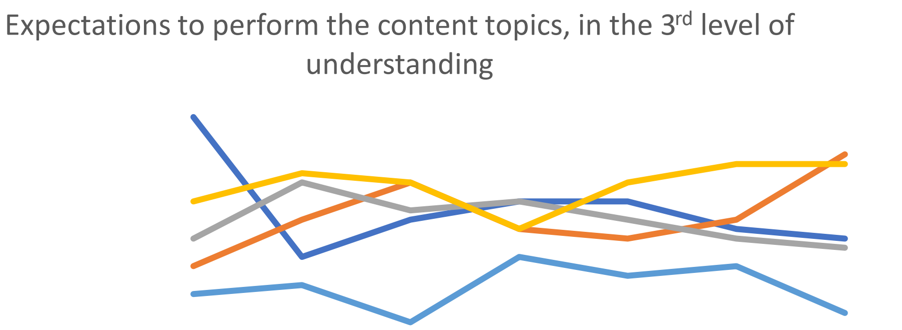
In the 2nd level of understanding (see Figure 47), the verb Presenting results gathers less preferences, with 18,2%, then followed by Differentiate (19,5%), Acquire habits/practice (23,6%) and lastly, the most frequent verb, Explore/experiment (32%). In this level, the verb Differentiate combined with Personal values and skills is the only one with 0 (zero) preferences.



	C	2D	3D	PVS	MT	T	VP
Acquire hab/practice	20,7	31	13,8	53,4	17,2	15,5	13,8
Differentiate	17,2	19	6,9	0	27,6	29,3	36,2
Present results	13,8	19	29,3	19	17,2	17,2	12,1
Explore/Experiment	43,1	25,9	46,6	20,7	25,9	27,6	34,5
None	5,2	5,2	3,4	6,9	12,1	10,3	3,4

Figure 47. Expectations to perform the LOs, in the 2nd level of understanding, using IVR-based tools (%).

The 3rd level of understanding is the level that presents less variability among the 4 verbs, starting with Criticize/judge/decide (20,7%), continuing with Integrate (21,4%), Analyse (22,7%), ending with the most frequent verb, Apply (27,1%), as presented in Figure 48.

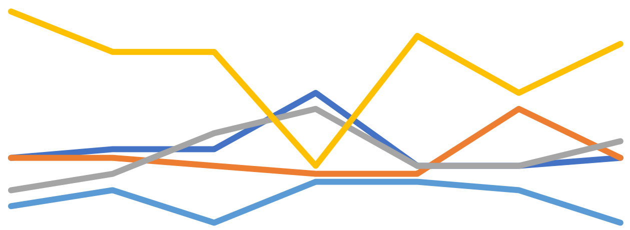


	C	2D	3D	PVS	MT	T	VP
Analyze	39,7	13,8	20,7	24,1	24,1	19	17,2
Integrate	12,1	20,7	27,6	19	17,2	20,7	32,8
Criticize/decide	17,2	27,6	22,4	24,1	20,7	17,2	15,5
Apply	24,1	29,3	27,6	19	27,6	31	31
None	6,9	8,6	1,7	13,8	10,3	12,1	3,4

Figure 48. Expectations to perform the LOs, in the 3rd level of understanding, using IVR-based tools (%).

In the 4th level of understanding (Figure 44), the verb Substantiate/prove has the less preferences (17,5%), followed by Master (18%), then by Reflect/contemplate (19,2%) and finally, Create/compose (37%). This is the most frequent verb of the 4th level and of all the 4 levels of understanding.

Expectations to perform the content topics, in the 4th level of understanding



	C	2D	3D	PVS	MT	T	VP
Reflect/contemplate	17,2	19	19	31	15,5	15,5	17,2
Substantiate/prove	17,2	17,2	15,5	13,8	13,8	27,6	17,2
To master	10,3	13,8	22,4	27,6	15,5	15,5	20,7
Create/compose	48,3	39,7	39,7	15,5	43,1	31	41,4
None	6,9	10,3	3,4	12,1	12,1	10,3	3,4

Figure 49. Expectations to perform the LOs, in the 4th level of understanding, using IVR-based tools (%).

It is relevant to point that despite the 4th level registers the most frequent verb (i.e., Create/compose) it is the least preferred level of all 4. The verb Create/compose is the verb that presents the highest preference of all verbs, in all the 4 levels.

Content topics

The content topic more expected to be learned using iVR-based tools is 3D principles of form creation (97,4%), closely followed by Visual principles (96,5%). Reversely, the content-topics perceived as less adequate to learn using iVR-based tools are Materials and Techniques (87,9%), short distanced from Personal values and skills (88,3%), Textures (88,7%), 2D principles of form creation (92,2%), and Colour (93,8%).

The content topic 3D principles of form creation is perceived as the most favourable to be learned using iVR-based tools, with 96,6% in the 2nd and 4th levels, equally, and more expected in the 1st and 3rd levels, both with 98,3% of the students preferences.

Visual principles is the 2nd most expected content topic, in which are highlighted the activities related to Identify and Integrate (32,8%), from the 1st and 3rd level, respectively; Differentiate (36,2%), from the 2nd level; and Create/compose (41,4%), from the 4th level.

The content topic Colour is the 3rd most expected, with the verbs Identify (36,2%), from the 1st level; Analyse (39,7%), from the 3rd level; Explore/experiment (43,1%) from the 2nd level; and Create/compose (48,3%), from the 4th level.

6.6. Discussion

The questionnaire aimed to assess the students' perceived expectations regarding the use iVR-based tools for achieving the LOs. In the context of designing learning activities, combinations of actions and content topics are also viewed Activity Units – AUs. These AUs integrate various learning activities, facilitating the attainment of LOs at the end of a learning cycle. As discussed in Chapter V, when structuring learning activities, educators and learning designers must define the AUs (i.e., actions involving the content topics) provided to students. This study contributes to the planning and design learning activities that incorporate AUs, enabling the achievement of LOs.

According to the proposed conceptual framework-model, learning a content topic requires its performance at different levels of understanding, either within the same learning activity or across multiple learning activities. This multifacted approach to cognitive dimensions, inspired by Johannes Itten's principles, emphasizes the interconnectedness of mind, body, and spirit, in Basic Design learning.

Overall, iVR-based tools are expected to assist the learning of all the BD-related content topics. However, there are higher expectations regarding their contributions to understanding 3D principles of form creation and Visual principles compared to Materials and techniques and Personal values and skills. Notably, the most challenging content topic to be learned appears to be 3D principles of form creation, where iVR-based tools are expected to be particularly helpful. Consequently, these findings suggest that future BD learning activities should strongly consider incorporating iVR-based tools for teaching-learning 3D principles. It is important to note that the most expected LOs to be achieved through iVR-based tools are related to the verbs "create" and "compose", underscoring the strong connection between BD and iVR in facilitating the creative process.

As previously mentioned, the 3D principles of form creation emerge as the most challenging content topic to learn, and they are also the ones most anticipated to benefit from iVR-based tools. However, the reverse is not true; the easiest content topic, Colour, doesn't rank lowest in terms of expectations for iVR-based learning - it actually comes in as the third most expected. On the other hand, Materials and techniques are perceived as the least likely content topic to be learned using iVR-based tools. This may be attributed to the recent pandemic-related contingency measures that favored the digital methods over the analog ones, limiting access to hands-on experience with materials.

Visual Principles, the 3rd easiest content topic, is considered highly suitable for learning through iVR-based tools. The second most challenging content topic, Texture, is not perceived as requiring iVR, possibly because VR systems still face challenges in conveying the realistic tactile sensations of touching and manipulating materials when compared to their strong visual and auditory effects. iVR-based tools are expected to be particularly valuable in overcoming difficulties associated with learning the most challenging content topic, such as 3D principles of form creation.

It's worth noting that although the content topic Personal values and skills is considered less suitable for iVR-based learning, there are still numerous opportunities to effectively apply these tools in this context. The results indicate that they can be valuable for reflective/contemplative activities, as reported by 31% of the participants, for practical exercises, according to 36,2%, and especially for acquiring habits and practice, which 53,4% of students expect to be the most beneficial learning outcome through iVR-based tools. This last combination stands out as the most anticipated, suggesting a potentially successful approach with significant contribution to an effective learning.

Personal values and skills, encompassing qualities like confidence, responsibility, inner peace, focus and concentration can, indeed be nurtured using iVR-based tools. For instance, iVR can facilitate contemplative moments in the virtual environments where students can reflect on their feelings and emotions, promote introspection, simulate real-life scenarios to develop empathetic feelings, such as understanding others' perspectives, foster non-judgmental attitudes, and encourage compassion and caring for others.

The verb “Create/compose” stands out as the most frequently chosen verb at the 4th level of understanding (see Figure 8) and, in fact, it is the most commonly preferred verb across all the levels of understanding, garnering 37% of the participants' preferences. It is noteworthy that the analysis of the BD study plans (Neves, Dias, Ramalho, et al., 2019) also highlights “create/compose” as the most representative verb at the 4th level of understanding. This underscores the strong anticipation that iVR-based tools can significantly enhance creativity in the teaching and learning context (see Tables 22-23; Figure 33). Consequently, it reinforces the likelihood of competences related to creativity benefiting positively from the use of iVR-based tools, making it a highly recommended approach in BD education.

Furthermore, the results also suggest a relative frequency of learning among the seven content topics, with some students having learned only learned a subset of them. Among these, Texture was the least learned, with 82,8% responses, followed by Materials & Techniques, with 94,8%. Conversely, Visual principles were learned by 96,6% of the students, and 3D form was acquired by 98,3%. The remaining three content topics; i.e., Colour; 2D form; and Personal values and skills, were learned by all participants. These findings align with the earlier information provided by Neves et al. (2019) regarding the analysis to the Portuguese BD study plans, indicating that Personal values & skills, and Design Fundamentals (Comprising Colour, 2D form, 3D form, and Visual principles) are the most frequently learned. Notably, Texture was absent from the Portuguese BD study plans (Neves, Dias, Duarte, et al., 2019), which might explain its relatively lower rate of acquisition (i.e., not learned by 17,2% of students, all Portuguese). Considering the mentioned study, it is somewhat unexpected that Texture is being learned at all, suggesting a potential recent inclusion of this content topic in design curricula and/or without being included in the analysed study plans.

Overall, IVR-based tools, as indicated by this study, have a high probability of enhancing engagement and facilitating effective learning across all content topics since they are all expected to be learned using iVR digital technological medium. This particularly crucial for addressing the most challenging content topic as perceived by the students: 3D principles of form creation.

We anticipate that the findings from this study will provide valuable support for the development of learning activities assisted by iVR-based tools. This approach is more likely to align with the expectations of future students, thus contributing to better teaching-learning experiences and learning outcomes.

6.7. Conclusions

Through an online questionnaire we gained insights into students' perceptions of their prior BD learning experiences, and their intentions regarding the use iVR-based tools for teaching-learning BD. The results suggest that despite most students' limited familiarity and proficiency with iVR digital technology, they view iVR-based tools as valuable and motivating aids in the learning process. Furthermore, these tools are anticipated to play a significant role in fostering creativity. It's worth noting that iVR-based tools are expected to support the learning of all the design fundamentals. However, the greatest expectations lie in the realm of learning 3D form, the most challenging content topic. This implies that iVR-based tools have substantial potential to help students overcome difficulties relating to 3D form.

The expectations for utilizing iVR-based tools to achieve the Los are high across all levels of understanding, but they are more pronounced at the 2nd level. At this level, activities involving exploration and experimentation are more welcomed, especially when related to 3D form. As a next step, it might be beneficial to develop a prototype of an iVR-based tool and test its effectiveness in teaching-learning 3D form. Given that comprehensive learning is often more effective when it encompasses all levels of understanding, it is advisable to design iVR-based tools that cover activities involving all the four levels of 3D principles of form creation, with a focus on the most preferred verbs that are likely to promote effective learning. For example, the tool could enable students to exercise symmetry operations (1st level), explore and experiment with various 3D forms in different virtual scenarios (2nd level), apply Gestalt principles in 3D pattern composition, and finally, create and compose a modular system. Such activities, infused with the motivation stemming from iVR-based tools, could prove highly beneficial.

Considering the potential for future scenarios, especially in the context of online Design courses or lockdown situations necessitated by events like the 2020-21 COVID-19 protective measures, the results obtained here can be employed and implemented seamlessly into remote iVR-based tools. This approach ensures that the attainment of LOs remains uninterrupted and effective.

6.8. Chapter Summary

To design effective BD learning activities with iVR-based tools, it is crucial to gauge student receptivity towards integrating iVR into the learning process. Learning activities are designed with the focus on the LOs, which are composed of the micro pedagogical elements: actions/verbs and content topics. Our study delves into students' perspectives on using iVR-based tools to facilitate BD learning, whether for the most challenging topic, 3D principles of form creation, or all topics. These insights can guide teachers and designers in creating engaging iVR-based BD tools, enhancing teaching and learning experiences, and ultimately boosting learning outcomes.

6.9. References

Abdelaziz, M., Riad, A., & Senousy, M. B. (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), 320–328.

Angelino, F. J. de A. (2020). *Exploring university students' engagement in learning through gamification, transmedia and virtual reality*. https://repositorio.iscte-iul.pt/handle/10071/20498

Ângulo, A., & Velasco, G. V. de. (2014). *Immersive Simulation of Architectural Spatial Experiences*. 495–499. https://doi.org/10.5151/despro-sigradi2013-0095

Baek, E.-O., Cagiltay, K., Boling, E., & Frick, T. (2008). User-Centered Design and Development. In J. M. Spector, M. D. Merrill, J. van Merrienboer, & M. P. Driscoll (Eds.), *Handbook of Research on Educational Communications and Technology: Third Edition* (3 edition, pp. 659–670). Routledge.

Bernardo, N., & Duarte, E. (2020). *Design, Education, and the Online Tech- Pandemic*. *13*(03), 10.

Biggs, J., & Tang, C. (2007). *Teaching For Quality Learning At University* (Edição: 3). Open University Press.

Bossard, C., Kermarrec, G., Buche, C., & Tisseau, J. (2008). Transfer of learning in virtual environments: A new challenge? *Virtual Reality*, *12*(3), 151–161. https://doi.org/10.1007/s10055-008-0093-y

Burdea, G. C., & Coiffet, P. (2003). *Virtual Reality Technology* (2 edition). Wiley-IEEE Press.

Colucci, K. (2011). What role will technology play in the future of design education. In *Icograda Design Education Manifesto 2011* (pp. 63–67). http://toolkit.icograda.org/database/rte/files/PR_IEN_Manifesto2011_webres.pdf

Dias, D. (2017). Learning Outcomes in European Higher Education. In P. Texeira & J. Shin (Eds.), *Encyclopedia of International Higher Education Systems and Institutions* (pp. 1–5). Springer Netherlands. https://doi.org/10.1007/978-94-017-9553-1_317-1

IBM Corp. (2020). *IBM SPSS statistics Algorithms* (Version 27) [Computer software]. IBM Corp.

International Organization of Standardization - ISO. (2010). *Ergonomics of human-system interaction -Part 210: Human-centred design for interactive systems (ISO 9241-210:2010)*. https://www.iso.org/standard/52075.html

International Organization of Standardization - ISO. (2019). *ISO 9241-210:2019*. ISO Online Browsing Platform. https://www.iso.org/cms/render/live/en/sites/isoorg/contents/data/standard/07/75/77520.html

Lee, E. A. L. (2011). *An investigation into the effectiveness of virtual reality-based learning* [Phd, Murdoch University]. http://researchrepository.murdoch.edu.au/4070/

Liu, Y. (2020). Future Step of Basic Design: Between Synaesthesia Didactic and Virtual Learning. In F. Tosi, A. Serra, A. Brischetto, & E. Lacono (Eds.), *Design for Inclusion, Gamification and Learning Experience* (FrancoAngeli).

Liu, Y., Riccò, D., & Calabi, D. (2019). A synaesthetic learning approach to cave. *3rd International Conference on Environmental Design*, 273–280.

Marôco, J. (2021). *Análise Estatística com o SPSS Statistics.: 8ª edição*. ReportNumber, Lda.

Merchant, Z., Goetz, E. T., Cifuentes, L., Keeney-Kennicutt, W., & Davis, T. J. (2014). Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis. *Computers & Education*, *70*, 29–40. https://doi.org/10.1016/j.compedu.2013.07.033

Nelson, H. G., & Stolterman, E. (2012). *The Design Way: Intentional Change in an Unpredictable World : Foundations and Fundamentals of Design Competence*. Educational Technology.

Neves, A. G., Dias, D., & Duarte, E. (2018). As Basic Design promotes the Design Learning: Featuring the Portuguese Higher Education setting. *ICERI2018 Proceedings*, 7663–7671. https://doi.org/10.21125/iceri.2018.0376

Neves, A. G., Dias, D., Duarte, E., & Ramalho, J. (2019). Back to the Basics of Basic Design: The Portuguese Scenario. *Proceedings of the 12th Annual International Conference of Education, Research and Innovation - ICERI'2019*, 416–425. https://doi.org/10.21125/iceri.2019.0139

Neves, A. G., Dias, D., Ramalho, J., & Duarte, E. (2019). Micro influence of Learning Outcomes in Basic Design. In E. Duarte & C. Rosa (Eds.), *Proceedings of the UNIDCOM 10th International Conference* (pp. 26–38). Edições IADE, Universidade Europeia.

Neves, A. G., & Duarte, E. (2015). Using Virtual Environments in Basic Design Education. In E. Duarte, C. Duarte, & F. Carvalho Rodrigues (Eds.), *Senses & Sensibility'15 Proceedings* (pp. 273–280). IADE - Creative University / Edições IADE.

Neves, A. G., Duarte, E., & Dias, D. (2018). Basic Design at IADE: Drawing the line. In E. Duarte (Ed.), *Design Doctoral Conference'18: TRANSgression. Proceedings of the DDC 5th Conference* (pp. 137–144). Edições IADE.

Neves, A. G., Duarte, E., & Dias, D. (2017). The impact of a Virtual Reality-based tool on teaching and learning Basic Design: Early perceptions. In E. Duarte (Ed.), *Design Doctoral Conference'17: TRANScendency Proceedings of the DDC 4th Conference* (pp. 167–174). Edições IADE.

Neves, A. G., Niemeyer, L., Duarte, E., Dias, D., Ayanoglu, H., Teixeira, L., Saraiva, M., & Martins, F. (2016). Learning Basic Design with Virtual Reality: A methodological approach. *EDULEARN16 Proceedings,* 5394–5402. https://doi.org/10.21125/edulearn.2016.2283

Obeid, S. (2019). *The Influence of Virtual Reality on Design Process Creativity in Basic Design Education* [Master]. Department of Interior Architecture and Environmental Design, İhsan Doğramacı Bilkent University.

Özgen, D. S., Afacan, Y., & Sürer, E. (2019). Usability of virtual reality for basic design education: A comparative study with paper-based design. *International Journal of Technology and Design Education*. https://doi.org/10.1007/s10798-019-09554-0

tom Dieck, M. C., Jung, T. H., & Loureiro, S. M. C. (Eds.). (2021). *Augmented Reality and Virtual Reality. New Trends in Immersive Technology*. Springer International Publishing.

Uysal, V. Ş., & Topaloğlu, F. (2017). Bridging the Gap: A Manual Primer into Design Computing in the Context of Basic Design Education. *International Journal of Art & Design Education*, *36*(1), 21–38. https://doi.org/10.1111/jade.12048

Zednik, E. (2020). *Taxonomia das Tecnologias Digitais na Educação: Aporte à cultura digital na sala de aula*. Editora SertãoCult.

Zednik, H., Tarouco, L. M. R., Klering, L., García-Valcárcel, A., & Guerra, E. P. M. (2014). Tecnologias Digitais na Educação: Proposta taxonômica para apoio à integração da tecnologia em sala de aula. *Anais do Workshop de Informática na Escola*, *20*(1), 507. https://doi.org/10.5753/cbie.wie.2014.507

Chapter VII

However careful one may be, to educate is to prune; let the branch that pleases us grow with all its strength.[28]

Agostinho da Silva

7. Conclusions and future developments

7.1. Conclusions

This work aims to advance innovative teaching-learning methods and tools in the BD context, supported by iVR digital technological medium. Through a series of successive studies, we have gained insights into how iVR-based tools can holistically enhance the teaching-learning of the design fundamentals. This approach can better prepare future designers to tackle complex socio-technical problems. Higher Education institutions globally, especially those following Los-based European system, can apply our conceptual framework-model to structure BD activities within any course. This involves applying the Activity Units to compose activities that align with the course outcomes and graduate attributes, contributing to a well-rounded educational experience.

7.1.1. Summary of the research

The research initially explored the theoretical integration of VR into BD pedagogy to facilitate innovative pedagogical approaches. It then progressed to a quasi-experimental study that involved creating a VR-based tool and using questionnaires for data collection. This initial study was conducted within a BD-derived course at IADE to assess the impact of the VR-based tool. While no significant differences were observed between the experimental and control groups, this can be attributed to the complexity of coordinating pedagogical activities and

[28] Free translation from the original: Por muito cuidado que se tenha,educar é podar; deixar crescer com toda a força o ramo que nos agrada.

experimental procedures. Nonetheless, students reported some satisfaction with the session. Subsequently, due to the impossibility to continue the research as planned, the focus shifted to identifying the most significant/critical BD competences in the Portuguese context that could be addressed by a VR-based tool. We mapped the BD courses in the Portuguese design education and identified Los, considering two main components: levels of understanding and content topics. The most frequent and important content topics were related to Personal values and skills and Design fundamentals. We also identified significant relationships between high(3)-relational level and content topic (B)-design fundamentals, as well as between the the same level of understanding and the content topic (E)-personal values and skills. These findings were organized in two conceptual matrixes that reflect, in some way, the structure of the Portuguese BD course, in terms of the mentioned LOs components, making them valuable for integrating BD learning tools.

The COVID-19 pandemic prompted a second restructuring phase, leading to a more theoretical approach. In this context, the third study culminated in the development of a conceptual framework-model designed to guide the creation of learning activities in the BD context. This framework-model is deeply rooted in the theoretical and philosophical foundations of BD, emphasizing holistic education. It draws inspiration from Johannes Itten's relation body-mind-spirit, as well as Findeli's concept of action-perception-aesthetics and Fernande's model that points to the involvement of all recursive orders for achieving human full potential. These concepts pertain to the macro-pedagogical dimension of BD, aligning with the cognitive functions underlying the levels of understanding, as reflected in the micro-pedagogical dimension, which encompasses LOs and AUs comprising content topics and levels of understanding, as defined by the constructive alignment theory (Biggs & Tang, 2007). This framework posits that key content topics should be engaged across all levels of understanding simultaneous during the learning process, thereby enhancing the potential for creating and sustaining a sense of presence during activities and, consequently, improving the experience and the learning. Importantly, the conceptual framework-model is agnostic to any specific technological medium, and its suitability should be evaluated based on its ability to enhance LOs.

The subsequent and the last study involved evaluating the conceptual framework-model for the designing iVR-based tools in the BD teaching-learning context within the HCD approach. An online questionnaire was devised using the previously identified conceptual matrices that form the Los, encompassing core content topics and levels of understanding. This, questionnaire facilitated the exploration of students' perceptions regarding past learning experiences and their expectations concerning the use of iVR-based tools in teaching-learning process and Los achievement. The results suggest that, despite most students' limited familiarity and proficiency with iVR digital technology, they perceived iVR-based tools as crucial and motivating for the learning journey, with high expectations for enhancing creativity. These iVR-based tools are anticipated to aid in mastering all the design fundamentals. However, there are particularly high expectations regarding their contribution to learning 3D form, a notably challenging content topic, suggesting that iVR-based tools have significant potential to alleviate difficulties associated with learning this content topic.

7.1.2. Impact of the findings

Sevaral conclusions can be drawn across different sectors of the HE system. For the European HE institutions that teach design fundamentals and employ LOs as a shared element bridging course outcomes, program outcomes and course graduate attributes, this study offers a conceptual framework-model. This framework can be used to develop BD learning activities based on AUs. This framework is not tied to a specific technological mediums and does not align exclusively with a particular pedagogical approach. Instead, it is aimed at institutions committed to delivering holistic design education across various pedagogical approaches.

For the HE institutions, this research can stimulate a systematic investment in the development and integration of VR-based tools within teaching-learning processes. In the realm of design education, it may serve as the initial step towards the wider adoption of VR in higher education. This adoption could entail "integrating low-budget mobile HMDs or the use of VR applications in a few selected lecture units over the entire semester" (Radianti et al.2020, p. 23), catering to both students preferences and the growing trend of remote learning experiences.

BD educators can use this study to heighten awareness regarding the significance of designing BD learning activities in alignment with holistic design principles. These activities, reinforced by iVR, can be more motivating, engaging and effective, even for remote learners. The proposed set of learning experiences can be analysed initially through the lens of the holistic conceptual framework-model. Subsequently, they can be fine-tuned, readjusted or reframed to ensure that all the cognitive dimensions are incorporated into the learning of the content topics. This approach offers a model for scrutinizing, critiquing, and enhancing BD courses and their associated learning activities.

Given the students' substantial interest in using iVR-based tools for various aspects of teaching-learning design fundamentals, adopting iVR alternatives is likely to lead to better performance of the LOs compared to alternatives lacking digital technology medium integration.

In summary, it is in the best interest of all stakeholders involved in teaching-learning design fundamentals to validate and fully implement the framework-model when designing of iVR-based tools and other tools resources geared toward holistic design education.

7.2. Future developments

To proceed with the design of iVR-based tool for BD context in the HE system, a crucial step involves validating the framework-model. To achieve this, it is imperative to continue the research by gathering input from BD teachers, faculty boards of the faculties, and computer engineers. This collaborative effort is essential for developing a holistic VR-based tool that will function effectively in a near future.

Guidance for developing BD learning activities assisted by iVR-based tools can be derived from Fernandez' (2017) 6-step model. This model outlines the developmental process for an AR/VR tool, starting with teacher training, conceptual prototypes, teamwork, immersive experience creation and, before the classroom implementation, a second teacher training moment (pedagogical transition where the Learning outcomes are defined). However, we emphasize that the definition of LOs should precede all stages of design to ensure their central role in shaping the system, aligning with the core principle of this study.

Once the LOs are clearly defined, the design of the VR-based tool can revolve around a set of Activity Units (AUs) for students. To maximize effective learning of any content topic, it is essential to incorporate actions/verbs from every level of understanding. This cognitive diversity is integral to a holistic pedagogical approach and can contribute to higher levels of creativity, a prominent objective in most design study programmes. The need for engaging with various levels of understanding when learning a content topic has a direct impact on creativity, as creativity often thrives on comprehensive knowledge.

Investing in VEs and VR, in particular, can provide a pathway for introducing future generations to creative activities like design. VR's unique features offer great opportunities for safe and cost-effective experimentation that would be challenging in conventional settings. The synergy between BD and VR can help alleviate anxiety, facilitate self-expression and unlock new dimensions of emotion discovery. By integrating VR, elements beyond the visual sphere, such as sound and body movement, can be incorporated, enhancing complexity and expressive potential in BD pedagogy. VR, with its immersive capabilities seen in headsets like "Oculus Quest and "HTC Vive" and complemented by haptic feedback devices like "Novint XIO", and "Dexmo F2", brings a sense of presence that other strategies hardly can match. Moreover, diverse perspectives, distances and scales can enhance perception skills, visualization, and imagery imagination, prompting creativity.

We hope that this study stimulates debate about the evolution of meaningful teaching and learning experiences in BD education, paving the way for innovative solution to be implemented.

7.3. Limits of the study

This study has its limitations as it primarily presents a theoretical framework-model that now requires validation. The initial step in this validation process involved gathering feedback from students regarding the framework-model's potential to support the development of VR-based tools. However, it is equally essential to evaluate this framework-model with educators and learning designers before proceeding with implementation. Additionally, it is important to note that the framework-model does not encompass task assessment considerations.

7.4. Rethinking the learning of the design fundamentals

In the early days of BD pedagogy, a primary goal was to nurture intuitive thinking. Intuition was considered important for approaching complex socio-technical systems in which all human activities are involved, from medicine to law (Findeli, 1994) and for building a sense of confidence and a leading character (Nelson & Stolterman, 2012). However, in contemporary design education, the emphasis on intuition has diminished, giving way to more rational and formalistic exercises. This shift has led to a decline in contemplative practices that were once integral to design education, as evident in our research on Portuguese BD education. conversely, contemplative practices, such as meditation, breathing exercises and other have gained prominence within the design practice (Findeli, 1994, 2018; Wahl, 2016). In the past century, scientific advances in neurosciences have highlighted the benefits of these practices, including enhanced learning in the higher education context (Barbezat & Bush, 2014; Davidson, 2012, 2017; Zajonc, 2013). We propose that future designers could greatly benefit from the revival of these foundational aspect of BD pedagogy, which can help foster intuitive thinking and tap into our inherent and natural human capabilities. This is especially pertinent in today's HE system, where the relentless march of digital technology often overshadows the holistic development of individuals.

Indeed, nurturing human natural capabilities is an essential aspect of any educational journey seeking to shape the character of a designer, as emphasized in "The Design Way" philosophy (Nelson & Stolterman, 2012). Especially in an era where digital technology permeates every facet of our existence, BD education should prioritize human flourishment and empowerment. In this context, the key consideration is how technology can be harnessed to enhance and refine these inherent human capacities. As mentioned by Moholy-Nagy:

> "Not the product, but man, is the end in view. Proceeding from such a basic readjustment we may work out an individual plan of life, with self-analysis as its background. Not the occupation, not the goods to be manufactured, ought to be put in the foreground, but rather recognition of man's organic function. With this functional preparation, he can then pass on to action, to a life evolved from within. We then lay down the basis for an organic system of production whose focal point is man, not profit." (Moholy-Nagy, 1947a, p. 17)

To address this challenge and reorient BD towards its essential role in fostering human capabilities, particularly students' intuition, the proposed framework-model offers a pathway to design learning activities that seamlessly incorporate the contemplative dimension. This dimension represents the highest cognitive level and can be integrated with or without the support of iVR-based tools.

7.5. Last considerations

Our proposal is to align future learning activities in the realm of design fundamentals more closely with the original BD premises, which emphasized the importance of incorporating self-knowledge dimension in the education of future designers. We acknowledge certain historical obstacles to these ideals: following its iconic beginning at the Bauhaus School of Design, Itten's breathing and relaxation exercises, rooted in religious-spiritual traditions, faced ridiculed (Itten, 1975). Additionally, the school to distanced itself from individual development during the influence of the last master of the Vorkurs, Joseph Albers, who believed that the personality development should occur after-school, as it could only be undertaken by the individual (Wick, 1993, p. 152). Bonsiepe recognized the Bauhaus propaedeutic course's intention to liberate and revitalize students' creative capacities, referring to it as a "therapeutic role" (Bonsiepe, 1992, p. 158).

However, designing learning experiences and activities that truly meet the needs of future designers and their innate capacity to service (Nelson & Stolterman, 2000), with the support of technology, requires prioritising the development of dimensions of human being. This includes fostering self-knowledge, self-learning, and the ability to learn (learning to learn), which are considered the building blocks of a fulfilling life and ethical, responsible design for all. While influenced by our personal experience, our framework-model emerged from deep reflection on how our roles and best intentions as educators could genuinely impact students' ability to thrive as lifelong designers, considering that design can be understood as a way of being and a way of living.

Revisiting the BD principles, in our case, means (re)considering human development as the central goal of HE, where any other skill or knowledge should be built upon and not treated in isolation. This is, in our opinion, the true essence of education, facilitating the growth of resilient, free, and responsible human beings.

According to Findeli (2018), the metamorphosis of the designer occurs when confronted with two counter forces inherent in a given project: the contextual forces of a social phenomena and the inner forces, its intentionality (Findeli, 2018, p. 111), and the images and ideas of himself.

> It requires the risk of taking a journey to one's inner space, where maybe one has never ventured before. And this is true, not only for the designer, but also, if the challenge of the phenomenological approach has been well understood, for all the stakeholders of the project. This is why the crucial task, for designers in such social design projects, is to learn how to co-design a space, both physical and social, where such risks may be safely taken and empathically welcomed by all stakeholders, and why designers need to acquire new

> competencies if they pretend to improve the habitability of the world for their fellow citizens. (Findeli, 2018, p. 113)

Designing the education of a designer, whether for a single course, an academix year, or an entire program, requires considering the entire learning experience rather than individual components in isolation. Thus, the framework-model presented in this research should be regarded as part of a broader context for teaching-learning design. It offers guidelines for creating learning activities that can be adapted to various pedagogical approaches. Hopefully, these findings will provide BD teachers and educational designers with a robust foundation for shaping the design of VR-based tools and, in turn, guide the future development of such tools for the BD context.

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Bibliography

Abdelaziz, M., Riad, A., & Senousy, M. B. (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), 320–328.

Adenauer, J., Israel, J. H., & Stark, R. (2013). Virtual Reality Technologies for Creative Design. In A. Chakrabarti (Ed.), *CIRP Design 2012* (pp. 125–135). Springer London. https://doi.org/10.1007/978-1-4471-4507-3_13

Agapito, D., Almeida, H., Cesário, M., Fernandes, S., & Lacerda, A. (2015). *Design em Portugal – O perfil do designer e o papel do design nas empresas em Portugal*. Sílabas & Desafios.

Almeida, L. S., Fernandes, E., Soares, A. P., Vasconcelos, R., & Freitas, A. C. (2003). Envolvimento académico: Confronto de expectativas e comporta- mentos em universitários do 1º ano. *Psicologia e Educação*, *II*(2), 14.

Almeida, V. (2009). *O Design em Portugal, um Tempo e um Modo. A institucionalização do Design Português entre 1959 e 1974* [Doutoramento, Faculdade de Belas Artes, Universidade de Lisboa]. http://repositorio.ul.pt/bitstream/10451/2485/2/ulsd059655_td_Tese_Victor_Almeida.pdf

Anceschi, G. (2010a). Design di base: Fondamenta del design. *Il Verri 'Newbasic'*, *43*. http://www.ilverri.it/index.php/la-rivista-del-verri/edizione-dal-1996/newbasic-detail

Anceschi, G. (2010b). Design di base: Fondamenta del design. *Il Verri 'Newbasic'*, *43*. http://www.ilverri.it/index.php/la-rivista-del-verri/edizione-dal-1996/newbasic-detail

ANECA. (2004). *Bibro Blanco. Títulos de grado en Bellas Artes/Diseño/Restauración*.

Angelino, F. J. de A. (2020). *Exploring university students' engagement in learning through gamification, transmedia and virtual reality*. https://repositorio.iscte-iul.pt/handle/10071/20498

Ângulo, A., & Velasco, G. V. de. (2014). *Immersive Simulation of Architectural Spatial Experiences*. 495–499. https://doi.org/10.5151/despro-sigradi2013-0095

Anita Rahardja & D. Rio Adiwijaya. (2011). Basic Design is Indeed for Expert. *Humaniora*, *2*(2), 925–931. https://doi.org/10.21512/humaniora.v2i2.3138

Atkinson, P., Delamont, S. (2011). SAGE Qualitative Research Methods. Los Angeles, CA: SAGE. *ISBN 9781849203784*.

Baek, E.-O., Cagiltay, K., Boling, E., & Frick, T. (2008). User-Centered Design and Development. In J. M. Spector, M. D. Merrill, J. van Merrienboer, & M. P. Driscoll (Eds.), *Handbook of Research on Educational Communications and Technology: Third Edition* (3 edition, pp. 659–670). Routledge.

Ball, C., Huang, K.-T., & Francis, J. (2021). Virtual reality adoption during the COVID-19 pandemic: A uses and gratifications perspective. *Telematics and Informatics*, *65*, 101728. https://doi.org/10.1016/j.tele.2021.101728

Bamford, A. (2011). *LiFE: Learning in Future Education Evaluation of innovation in learning using emerging technologies* [Project].

Barbezat, D. P., & Bush, M. (2014). *Contemplative Practices in Higher Education: Powerful Methods to Transform Teaching and Learning* (1 edition). Jossey Bass.

Bayirli, Ü. (2015). *Evaluation of Basic Design education at METU department of Industrial Design* [Master]. Graduate School of Natural and Applied Sciences of Middle East Technical University.

Bernardo, N., & Duarte, E. (2020). *Design, Education, and the Online Tech- Pandemic*. *13*(03), 10.

Besgen, A., Kuloglu, N., & Fathalizadehalemdari, S. (2015). Teaching/Learning Strategies Through Art: Art and Basic Design Education. *Procedia - Social and Behavioral Sciences*, *182*, 428–432. https://doi.org/10.1016/j.sbspro.2015.04.813

Biggs, J. (2003). Aligning Teaching and Assessment to Curriculum Objectives. *Proceedings of the International Conference on Teaching and Learning in Higher Education*. International Conference on Teaching and Learning in Higher Education: New Trends and Innovations, Aveiro, Portugal, 13-17 April 2003, Aveiro, Portugal.

Biggs, J., & Tang, C. (2007). *Teaching For Quality Learning At University* (Edição: 3). Open University Press.

Bologna Process Committee (1999). *Joint declaration of the European Ministers of Education convened in Bologna on 19 June 1999*. (The Bologna Declaration). ec.europa.eu/education/policies/educ/bologna/bologna.pdf

Bonsiepe, G. (1992). *Teoria e prática do design industrial: Elementos para um manual crítico* (1992nd-1ª ed portuguesa ed.). Centro Português de Design.

Bonsiepe, G. (1999). *Del Objeto a la Interfase*. Ediciones Infinito.

Bonsiepe, G. (2007). The Uneasy Relationship between Design and Design Research. In R. Michel (Ed.), *Design Research Now: Essays and Selected Papers* (pp. 25–39). Birkhäuser Architecture.

Bonsiepe, G. (2011). *Design, Cultura e Sociedade*. Edgard Blucher.

Bonsiepe, G. (2012). *Design como Prática de Projeto*. Edgard Blucher.

Bonsiepe, G. (2019). *On the heteronomy of design in a post-utopian age* [Draft].

Bordegoni, M., Ferrise, F., & Cugini, U. (2013). Development of Virtual Prototypes Based on Visuo/Tactile Interaction for the Preliminary Evaluation of Consumer Products Usage. In A. Chakrabarti (Ed.), *CIRP Design 2012* (pp. 149–158). Springer London. https://doi.org/10.1007/978-1-4471-4507-3_15

Bossard, C., Kermarrec, G., Buche, C., & Tisseau, J. (2008). Transfer of learning in virtual environments: A new challenge? *Virtual Reality*, *12*(3), 151–161. https://doi.org/10.1007/s10055-008-0093-y

Boucharenc, C. (2006a). Research on Basic Design Education: An International Survey. *International Journal of Technology and Design Education*, *16*(1), 1–30.

Boucharenc, C. G. (2006b). Research on Basic Design Education: An International Survey. *International Journal of Technology and Design Education*, *16*(1), 1–30. https://doi.org/10.1007/s10798-005-2110-8

Buchanan, R. (2001). Design Research and the New Learning. *Design Issues*, *17*(4), 3–23. https://doi.org/10.1162/07479360152681056

Burdea, G. C., & Coiffet, P. (2003). *Virtual Reality Technology* (2 edition). Wiley-IEEE Press.

Burnette, C. H. (2009). *A Theory of Design Thinking*. https://www.academia.edu/209385/A_Theory_of_Design_Thinking

Carvalho, A. A. A. (2011). *A teoria da flexibilidade cognitiva e o modelo múltiplas perspectivas*. http://repositorium.sdum.uminho.pt/handle/1822/15921

Carvalho, A. A., Araújo, I., Zagalo, N., Gomes, T., Barros, C., Moura, A., & Cruz, S. (2014). Os jogos mais jogados pelos alunos do Ensino Básico ao Ensino Superior. In A. Carvalho, S. Cruz, C. Marques, A. Moura, & I. Santos (Eds.), *Atas do 2º Encontro sobre Jogos e Mobile Learning* (pp. 74–84). Universidade do Minho. Instituto de Educação. Centro de Investigação em Educação (CIEd).

Cetinkaya, C. (2014). Basic Design Education Parameters in Turkey. In *Humanitas International Journal of Social Sciences* (pp. 31–46). Central and Eastern European Online Library.

Cindioglu, H. C., Gursel Dino, I., & Surer, E. (2021). Proposing a novel mixed-reality framework for basic design and its hybrid evaluation using linkography and interviews. *International Journal of Technology and Design Education*. https://doi.org/10.1007/s10798-021-09707-0

Colucci, K. (2011). What role will technology play in the future of design education. In *Icograda Design Education Manifesto 2011* (pp. 63–67). http://toolkit.icograda.org/database/rte/files/PR_IEN_Manifesto2011_webres.pdf

Costa, D. da. (2001). *Curriculum Vitae*.

Cracel, M. da C., Dias, G. D., & Correia, M. N. (2014). *Quatro Ontagogos de Portugal. António Sérgio, Almada Negreiros, Adolfo Coelho e Ramalho Ortigão* (J. C. Casulo, Ed.). Estratégias Criativas.

Creswell, J. W. (2013). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, 4th Edition* (4th edition). SAGE Publications, Inc.

Creswell, J. W., & Clark, V. L. P. (2017). *Designing and Conducting Mixed Methods Research* (Third edition). SAGE Publications, Inc.

Cross, A. (1983). The educational background to the Bauhaus. *Design Studies*, *4*(1), 43–52. https://doi.org/10.1016/0142-694X(83)90007-8

Cruz, S. (2010). *Proposta de um modelo de integração das tecnologias de informação e comunicação nas práticas lectivas: O aluno de consumidor crítico a produtor de informação online*. http://repositorium.sdum.uminho.pt/handle/1822/10678

Dalgarno, B., & Lee, M. (2010). What are the learning affordances of 3-D virtual environments? *British Journal of Educational Technology*, *41*(1), 10–32.

Davidson, C. N. (2012). *Now You See It: How Technology and Brain Science Will Transform Schools and Business for the 21st Century* (Reprint edition). Penguin Books.

Davidson, C. N. (2017). *The New Education: How to Revolutionize the University to Prepare Students for a World In Flux* (1 edition). Basic Books.

Davis, M. (2017). *Teaching Design: A Guide to Curriculum and Pedagogy for College Design Faculty and Teachers Who Use Design in Their Classrooms*. Allworth.

Dehaene, S. (2020). *How We Learn: Why Brains Learn Better Than Any Machine . . . for Now*. Viking.

Desmet, P. (2003). Measuring Emotion: Development and Application of an Instrument to Measure Emotional Responses to Products. In M. A. Blythe, K. Overbeeke, A. F. Monk, & P. C. Wright (Eds.), *Funology* (pp. 111–123). Springer Netherlands. https://doi.org/10.1007/1-4020-2967-5_12

Desmet, P., Pohlmeye, A., & Forlizzi, J. (2013). Design for Subjective Well-Being. *International Journal of Design*, *7*(3), 1–3.

Dias, D. (2017). Learning Outcomes in European Higher Education. In P. Texeira & J. Shin (Eds.), *Encyclopedia of International Higher Education Systems and Institutions* (pp. 1–5). Springer Netherlands. https://doi.org/10.1007/978-94-017-9553-1_317-1

Droste, M. (1992). *Bauhaus 1919-1933*. Taschen.

D'Souza, N., Yoon, S.-Y., & Islam, Z. (2011). Understanding design skills of the Generation Y: An exploration through the VR-KiDS project. *Design Studies*, *32*(2), 180–209. https://doi.org/10.1016/j.destud.2010.07.002

Feenberg, A. (1991). *Critical Theory of Technology*. Oxford University Press, New York, 1991.

Federle, G. (2009). *Basic Design La formazione al design nella Scuola secondaria* [Doutoramento, Università Ca' Foscari Venezia]. http://dspace.unive.it/bitstream/handle/10579/1016/Tesi_Federle_2010.pdf?sequence=1

Fernandes, R. (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.* (http://eprints.ucm.es/12198/1/T32379.pdf). Universidade Complutense de Madrid.

Fernandez, M. (2017). Augmented Virtual Reality: How to Improve Education Systems. *Higher Learning Research Communications*, *7*(1), 1–15.

Findeli, A. (1990). Moholy-Nagy's Design Pedagogy in Chicago (1937-46). *Design Issues*, *7*(1), 4–19. https://doi.org/10.2307/1511466

Findeli, A. (1994). Ethics, Aesthetics, and Design. *Design Issues*, *10*(2), 49–68. https://doi.org/10.2307/1511628

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

Findeli, A. (2018). The Metamorphosis of the Designer: A Prerequisite to Social Transformation by Design. In M. Förster, S. Hebert, M. Hofmann, & W. Jonas (Eds.), *Un/Certain Futures—Rollen des Designs in gesellschaftlichen Transformationsprozessen* (1. Edition, pp. 104–113). transcript Verlag.

Flusser, V. (2013). *The Shape of Things: A Philosophy of Design*. Reaktion Books.

Flusser, V. (2018). *O mundo codificado: Por uma filosofia do design e da comunicação*. Ubu Editora.

Frascara, J. (2020). Design Education, Training, and the Broad Picture: Eight Experts Respond to a Few Questions. *She Ji: The Journal of Design, Economics, and Innovation*, *6*(1), 106–117. https://doi.org/10.1016/j.sheji.2019.12.003

Friedman, K. (2019). *Design Education Today. Challenges, Opportunities, Failures*. https://www.academia.edu/40519668/Friedman._2019._Design_Education_Today_-_Challenges_Opportunities_Failures?email_work_card=view-paper

Fuller, R. B. (2002). *Critical Path* (2nd Revised edition edition). Saint Martin's Griffin,U.S.

Fuller, R. B. (2008). *Grunch of Giants*. Design Science.

Fulton Suri, J., & Marsh, M. (2000). Scenario building as an ergonomics method in consumer product design. *Applied Ergonomics*, *31*(2), 151–157. https://doi.org/10.1016/S0003-6870(99)00035-6

Gelmez, K., & Bagli, H. (2015). Learning from Students: Reflections from personal magazines in basic design course. *Design and Technology Education: An International Journal*, *20*(1). http://ojs.lboro.ac.uk/ojs/index.php/DATE/article/view/2019

González, J., & Wagenaar, R. (Eds.). (2008). *Tuning Educational Strucures in Europe. Universities contribution to the Bologna Process. An introduction* (2ª). Publicaciones de la Universidad de Deusto.

Gu, N., Gul, L. F., & Williams, A. (2010). Methods for evaluating 3D Virtual Worlds in Design Education. *International Design Conference - Design 2010*, 1259–1266.

Guerini, S. (2001). *Il Corpo Risponde. Le sinestesie nella didattica multimediale* [Licenciatura, Politecnico di Milano]. https://issuu.com/silviaguerini/docs/il_corpo_risponde_silvia_guerini_ca

Gul, L. F. (2009). Studying the Impact of Immersion on Design Cognition. *Computation: The New Realm of Architectural Design: 27th ECAADe Conference Proceedings*, 615–622.

Heim, M. (1994). *The Metaphysics of Virtual Reality*. Oxford University Press USA.

Heim, M. (1998). *Virtual Realism*. Oxford University Press.

IBM Corp. (2020). *IBM SPSS statistics Algorithms* (Version 27). IBM Corp.

International Organization of Standardization - ISO. (2019). *ISO 9241-210:2019*. ISO Online Browsing Platform. https://www.iso.org/cms/render/live/en/sites/isoorg/contents/data/standard/07/75/77520.html

Itten, J. (1975). *Design and Form: Basic Course at the Bauhaus* (Revised edition edition). Titles Supplied by John Wiley & Sons Australia.

Johnson, L., Adams Becker, S., Estrada, V., & Freeman, A. (2014). *MC Horizon Report—2014 Higher Education Edition*. http://www.nmc.org/pdf/2014-nmc-horizon-report-he-EN.pdf

Jones, D. (2013). An Alternative (to) Reality. In M. Childs & A. Peachey (Eds.), *Understanding Learning in Virtual Worlds* (pp. 1–20). Springer.

Kavanagh, S., Luxton-Reilly, A., Wuensche, B., & Plimmer, B. (2017). A Systematic Review of Virtual Reality in Education. *Themes in Science and Technology Education*, *10*(2), 85–119.

Keller, J. M. (2010). *Motivational Design for Learning and Performance*. Springer US. http://link.springer.com/10.1007/978-1-4419-1250-3

Knauer, R. (2008). *Transformation. Basic Principles and Methodology of Design* (1st ed.). Birkhäuser GmbH.

Lanyi, C. (Ed.). (2012). *Applications of Virtual Reality*. InTech.

Lau, K. W., & Lee, P. Y. (2015). The use of virtual reality for creating unusual environmental stimulation to motivate students to explore creative ideas. *Interactive Learning Environments*, *23*(1), 3–18. https://doi.org/10.1080/10494820.2012.745426

Lee, E. A. L. (2011). *An investigation into the effectiveness of virtual reality-based learning* [Phd, Murdoch University]. http://researchrepository.murdoch.edu.au/4070/

Lerner, F. (2005). Foundations for Design Education: Continuing the Bauhaus Vorkurs Vision. *Studies in Art Education*, *46*(3), 211–226.

Liu, Y. (2020). Future Step of Basic Design: Between Synaesthesia Didactic and Virtual Learning. In F. Tosi, A. Serra, A. Brischetto, & E. Lacono (Eds.), *Design for Inclusion, Gamification and Learning Experience* (FrancoAngeli).

Liu, Y., Riccò, D., & Calabi, D. (2019). A synaesthetic learning approach to cave. *3rd International Conference on Environmental Design*, 273–280.

Magalhães, C. (2004). *O pensamento antropagógico de Agostinho da Silva* [Doutoramento]. Universidade do Porto, Faculdade de Letras.

Marcolli, A. (1971). *Teoria del Campo—Corso di educazione alla visione* (1998th, 17ªed ed.). Sansoni Editore.

Marcolli, A. (1978). *Teoria del Campo 2—Corso di metodologia dalla visione* (1991st, 3ª ed. ed.). Sansoni Editore.

Marks, B., & Thomas, J. (2022). Adoption of virtual reality technology in higher education: An evaluation of five teaching semesters in a purpose-designed laboratory. *Education and Information Technologies*, *27*(1), 1287–1305. https://doi.org/10.1007/s10639-021-10653-6

Marôco, J. (2021). *Análise Estatística com o SPSS Statistics.: 8ª edição*. ReportNumber, Lda.

Maturana Educar es amar. (2017, August 2). https://www.youtube.com/watch?v=8bbO1vx-ILQ

Maturana R., H., & Varela G., F. (2004). *De máquinas y seres vivos* (6th ed.). Lumen.

Mcluhan, M., & Lapham, L. H. (1994). *Understanding Media: The Extensions of Man* (New Ed edition). MIT Press.

Merchant, Z., Goetz, E. T., Cifuentes, L., Keeney-Kennicutt, W., & Davis, T. J. (2014). Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis. *Computers & Education*, *70*, 29–40. https://doi.org/10.1016/j.compedu.2013.07.033

Meyer, M. W., & Norman, D. (2020). Changing Design Education for the 21st Century. *She Ji: The Journal of Design, Economics, and Innovation*, *6*(1), 13–49. https://doi.org/10.1016/j.sheji.2019.12.002

Milgram, P., Takemura, H., Utsumi, A., & Kishino, F. (1995). Augmented Reality: A class of displays on the reality-virtuality continuum. *Proc. SPIE 2351, Telemanipulator and Telepresence Technologies*. Telemanipulator and Telepresence Technologies. https://doi.org/10.1117/12.197321

Moholy-Nagy, L. (1947a). *The New Vision and Abstract of an Artist* (1928 Fourth revised Edition 1947 edition). George Wittenborn Inc.

Moholy-Nagy, L. (1947b). *Vision in Motion*. Wisconsin Cuneo Press.

Monache, S., & Rocchesso, D. (2014). Bauhaus Legacy in Research through Design: The Case of Basic Sonic Interaction Design. *International Journal of Design International Journal of Design [Online]*, *8*(3). http://www.ijdesign.org/ojs/index.php/IJDesign/article/view/1543/657#3

Monteiro, R., & Barbosa, H. (2014). Challenges Game: Um jogo dinamizador do processo de ensino. In A. Carvalho, S. Cruz, C. Marques, A. Moura, & I. Santos (Eds.), *Atas do 2º Encontro sobre Jogos e Mobile Learning* (pp. 74–84). Universidade do Minho. Instituto de Educação. Centro de Investigação em Educação (CIEd).

Morais, M. de F., Almeida, L. S., Azevedo, I., Alencar, E., & Fleith, D. (2014). Inventory of barriers to personal creativity: A validation study involving university students. *The European Procedia Social and Behavioural Sciences Ep-SBS*, 135–146. https://doi.org/10.15405/epsbs.2014.05.16

Munari, B. (1979). *Arista e Designer*. Editorial Presença/Martins Fontes.

Munari, B. (1995). *Design e Comunicação Visual*. Edições 70.

Munari, B. (1998). *Design e Comunicação Visual* (1 edition). Martins Fontes.

Nardi, B. A. . A. (1992). The use of scenarios in design. *SIGCHI Bull*, *24*(3), 13–14.

Nelson, H. (n.d.). *Systemics—The Logics of Design*. Retrieved 18 April 2021, from https://www.academia.edu/11394542/Systemics_the_Logics_of_Design

Nelson, H. G., & Stolterman, E. (2012). *The Design Way: Intentional Change in an Unpredictable World : Foundations and Fundamentals of Design Competence*. Educational Technology.

Nelson, H., & Stolterman, E. (2000). Design as Being in Service. In D. Durling & K. Friedman (Eds.), *Domains of Design Knowledge. Proceedings of the conference Doctoral Education in Design: Foudations for the Future* (pp. 6–16). Staffordshire University Press, UK. https://www.academia.edu/11772998/Domains_of_Design_Knowledge_Edited_by_David_Durling_Ph.D._and_Ken_Friedman_Ph.D

Neves, A., Dias, D., & Duarte, E. (2018). As Basic Design promotes the Design Learning: Featuring the Portuguese Higher Education setting. *ICERI2018 Proceedings*, 7663–7671. https://doi.org/10.21125/iceri.2018.0376

Neves, A., Dias, D., Duarte, E., & Ramalho, J. (2019). Back to the Basics of Basic Design: The Portuguese Scenario. *Proceedings of the 12th Annual International Conference of Education, Research and Innovation - ICERI'2019*, 416–425. https://doi.org/10.21125/iceri.2019.0139

Neves, A., Dias, D., Ramalho, J., & Duarte, E. (2019). Micro influence of Learning Outcomes in Basic Design. In E. Duarte & C. Rosa (Eds.), *Proceedings of the UNIDCOM 10th International Conference* (pp. 26–38). Edições IADE, Universidade Europeia. http://senses2019.unidcom-iade.pt/wp-content/uploads/2020/12/Proceedings-of-the-

10th-International-Conference-SensesSensibility-2019-Lost-in-Glocalization-final-version_medium.pdf

Neves, A., & Duarte, E. (2015a). Using Virtual Environments in Basic Design Education. In E. Duarte, C. Duarte, & F. Carvalho Rodrigues (Eds.), *Senses & Sensibility'15: Design as a Trade Proceedings of the UNIDCOM/IADE 8th International Conference* (pp. 273–280). IADE - Creative University / Edições IADE.

Neves, A., & Duarte, E. (2015b). Using Virtual Environments in Basic Design Education. In E. Duarte, C. Duarte, & F. Carvalho Rodrigues (Eds.), *Senses & Sensibility'15 Proceedings* (pp. 273–280). IADE - Creative University / Edições IADE.

Neves, A., Duarte, E., & Dias, D. (2016). Basic Design meets Virtual Reality: A tentative methodology. *Design Doctoral Conference'16: TRANSversality. Proceedings of the DDC 3rd Conference*, 104–111. http://iade.us11.list-manage.com/track/click?u=bf2ccdc18181c0504e5a4099c&id=e01959960c&e=0698e9a4a1

Neves, A., Duarte, E., & Dias, D. (2017). The impact of a Virtual Reality-based tool on teaching and learning Basic Design: Early perceptions. In E. Duarte (Ed.), *Design Doctoral Conference'17: TRANScendency Proceedings of the DDC 4th Conference* (pp. 167–174). Edições IADE.

Neves, A., Duarte, E., & Dias, D. (2018). Basic Design at IADE: Drawing the line. In E. Duarte (Ed.), *Design Doctoral Conference'18: TRANSgression. Proceedings of the DDC 5th Conference* (pp. 137–144). Edições IADE.

Neves, A., Niemeyer, L., Duarte, E., Dias, D., Ayanoglu, H., Teixeira, L., Saraiva, M., & Martins, F. (2016). Learning Basic Design with Virtual Reality: A methodological approach. *EDULEARN16 Proceedings*, 5394–5402. https://doi.org/10.21125/edulearn.2016.2283

Norman, D. A. (2016). When You Come to a Fork in the Road, Take It: The Future of Design*. *She Ji: The Journal of Design, Economics, and Innovation*, *2*(4), 343–348. https://doi.org/10.1016/j.sheji.2017.07.003

Obeid, S. (2019). *The Influence of Virtual Reality on Design Process Creativity in Basic Design Education* [Master]. Department of Interior Architecture and Environmental Design, İhsan Doğramacı Bilkent University.

OECD. (2012). *Assessment of Higher Education Learning Outcomes AHELO. Feasibility Study Report, vol 1 – Design and Implementation* (volume 1).

Özgen, D. S., Afacan, Y., & Sürer, E. (2019). Usability of virtual reality for basic design education: A comparative study with paper-based design. *International Journal of Technology and Design Education*. https://doi.org/10.1007/s10798-019-09554-0

Parashar, S. (2010). Basic Design Studio, an ongoing research. *Proceedings of the 2010 International Conference on Architectural Research The Place of Research/ The Research of Place*, 523–536. http://www.google.pt/url?sa=t&rct=j&q=innovation_in_design_education&source=web&cd=1&cad=rja&ved=0CCwQFjAA&url=http%3A%2F%2Fwww.allemandi.com%2Funiversity%2FInnovation_in_Design_Education.pdf&ei=er0MU4S6Ka3y7Abu94DABA&usg=AFQjCNHYtFt7J0ltBnv9q6XOx-5LTeCdyw&bvm=bv.61725948,d.bGQ

Radianti, J., Majchrzak, T. A., Fromm, J., & Wohlgenannt, I. (2020a). A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. *Computers & Education*, *147*, 103778. https://doi.org/10.1016/j.compedu.2019.103778

Radianti, J., Majchrzak, T. A., Fromm, J., & Wohlgenannt, I. (2020b). A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. *Computers & Education*, *147*, 103778. https://doi.org/10.1016/j.compedu.2019.103778

Read, H. (2007). *Educação pela Arte*. Edições 70.

Rebelo, F., Duarte, E., Noriega, P., & Soares, M. M. (2011). Virtual Reality in Consumer Product Design: Methods and Applications. In Waldemar Karwowski, Marcelo M. Soares, & Neville A. Stanton (Eds.), *Human Factors and Ergonomics in Consumer Product Design: Methods and Techniques* (pp. 381–402). CRC Press.

Redström, J. (2020). Certain Uncertainties and the Design of Design Education. *She Ji: The Journal of Design, Economics, and Innovation*, *6*(1), 83–100. https://doi.org/10.1016/j.sheji.2020.02.001

Riccò, D., Belluscio, A., & Guerini, S. (2003). Design for the synesthesia. Audio, visual and haptic correspondences experimentation. *Proceedings of the Senses and Sensibility in Technology –Linking Tradition to Innovation through Design*, 159–164.

Riccò, D., & Guerini, S. (2002). Synesthetic Design. The Laboratory of Basic Design as place of experimentation on the intersensory correspondences. *Proceedings of the 3rd Annual Meeting of the International Multisensory Research Forum. Geneva, Switzerland, May 2002*, 159–164.

Sausmarez, M. de. (1995). *Diseño básico: Dinámica de la forma visual en las artes plásticas*. Gustavo Gili.

Schank, R. C. (2011). *Teaching Minds: How Cognitive Science Can Save Our Schools*. Teachers College Press.

Sharples, S., Cobb, S., Moody, A., & Wilson, J. R. (2008). Virtual reality induced symptoms and effects (VRISE): Comparison of head mounted display (HMD), desktop and projection display systems. *Displays*, *29*(2), 58–69. https://doi.org/10.1016/j.displa.2007.09.005

Sik Lányi, C., Lányi, Z., & Tilinger, A. (2003). Using Virtual Reality to Improve Space and Depth Perception. *Journal of Information Technology Education, 2*, 291–303.

Simon, H. A. (1996). *The Sciences of the Artificial* (3rd edition). MIT Press.

Sorby, S. A. (1999). Developing 3-D Spatial Visualization Skills. *Engineering Design Graphics Journal*, *63*(2), 21–33.

Souto, M. H. (2001). Daciano da Costa e o ensino do Design em Portugal. In *Daciano da Costa Designer* (Fundação Calouste Gulbenkian, pp. 34–41).

Spiro, R. J., Collins, B. P., & Ramchandran, A. R. (2007). Modes of Openness and Flexibility in Cognitive Flexibility Hypertext Learning Environments. In B. H. Khan (Ed.), *Flexible Learning in an Information Society*. Idea Group Inc (IGI).

tom Dieck, M. C., Jung, T. H., & Loureiro, S. M. C. (Eds.). (2021). *Augmented Reality and Virtual Reality. New Trends in Immersive Technology*. Springer International Publishing.

Uysal, V. Ş., & Topaloğlu, F. (2017). Bridging the Gap: A Manual Primer into Design Computing in the Context of Basic Design Education. *International Journal of Art & Design Education*, *36*(1), 21–38. https://doi.org/10.1111/jade.12048

Wahl, D. C. (2016). *Designing Regenerative Cultures*. Triarchy Press Ltd.

Wei, X., Weng, D., Liu, Y., & Wang, Y. (2015). Teaching based on augmented reality for a technical creative design course. *Computers & Education, 81*, 221–234. https://doi.org/10.1016/j.compedu.2014.10.017

Wick, R. (1993). *La pedagogía de la Bauhaus* (B. B. Álvarez, Trans.; Edición: edición). Alianza.

Wiggins, G., & McTighe, J. (2005). *Understanding By Design* (2nd Expanded edition). Assn. for Supervision & Curriculum Development.

Wong, W. (1995). *Fundamentos del diseño* (4ª). Gustavo Gili.

Yaghan, M., & Ashour, R. (2008). The Battle of Grids: Preparing first year students for their upcoming design studies in Jordan. In *Designing Design Education Proceedings: Vol. Part II* (pp. 210–223). Designtrain Congress. http://www.elia-artschools.org/images/products/17/part_2.pdf

Zajonc, A. (2013). Contemplative Pedagogy: A Quiet Revolution in Higher Education. *New Directions for Teaching and Learning*, *2013*(134), 83–94. https://doi.org/10.1002/tl.20057

Zednik, E. (2020). *Taxonomia das Tecnologias Digitais na Educação: Aporte à cultura digital na sala de aula*. Editora SertãoCult.

Zednik, H., Tarouco, L. M. R., Klering, L., García-Valcárcel, A., & Guerra, E. P. M. (2014). Tecnologias Digitais na Educação: Proposta taxonômica para apoio à integração da tecnologia em sala de aula. *Anais do Workshop de Informática na Escola*, *20*(1), Article 1. https://doi.org/10.5753/cbie.wie.2014.507

Dissemination (Annex L)

Neves, A. G., & Duarte, E. (2015). Using Virtual Environments in Basic Design Education. In E. Duarte, C. Duarte, & F. Carvalho Rodrigues (Eds.), Senses & Sensibility'15: Design as a Trade Proceedings of the UNIDCOM/IADE 8th International Conference (pp. 273–280). Lisboa, Portugal: IADE -- Creative University / Edições IADE. https://www.unidcom-iade.pt/wp-content/uploads/2018/07/Proceedings_SS15.pdf

Neves, A. G., & Duarte, E. (2016). Using Virtual Environments in Basic Design Education. *The Radical Designist* (Senses & Sensibility'15 ThRAD Special Issue). http://www.iade.pt/unidcom/radicaldesignist/wp-content/uploads/2016/02/ThRad-SS15__ANeves-EDuarte.pdf

Neves, A.G., Duarte, E. & Dias, Diana (2016). Basic Design meets Virtual Reality: A tentative methodology. Em *Design Doctoral Conference Proceedings* (pp. 104-111). Lisboa, Portugal: IADE -Creative University / Edições IADE. http://unidcom.iade.pt/ddc16/wp-content/uploads/2016/07/Proceedings-e-Book.pdf

Neves, A. G., Niemeyer, L., Duarte, E., Dias, D., Ayanoğlu, H., Teixeira, L., … Martins, F. (2016). Learning Basic Design with Virtual Reality: A methodological approach. Em *EDULEARN16 Proceedings, 8th International Conference on Education and New Learning Technologies, July 4th-6th, 2016* – Barcelona, Spain (pp. 5394-5402). doi: 10.21125/edulearn.2016.2283

Neves, A.G., Duarte, E., Dias, D. & Saraiva, M. (2017). The impact of a Virtual Reality-based tool on teaching and learning Basic Design: Early perceptions. Em *Design Doctoral Conference'17: TRANScendency, Proceedings of the DDC 4th Conference* (pp. 167-174). Lisboa, Portugal: IADE -Creative University / Edições IADE. https://www.unidcom-iade.pt/wp-content/uploads/2018/09/DDC17-Proceedings.pdf

Neves, A.G., Duarte, E. & Dias, D. (2018). Basic Design at IADE: Drawing the line. Em E. Duarte (Ed.), *Design Doctoral Conference'18: TRANSgression. Proceedings of the DDC*

5th Conference (pp. 137–144). Universidade Europeia, IADE, Lisboa: Edições IADE. https://www.unidcom-iade.pt/wp-content/uploads/2018/11/DDC-18-web.pdf

Neves, A. G., Dias, D., & Duarte, E. (2018). As Basic Design promotes the design learning: Featuring the Portuguese Higher Education setting. Em L. Gómez Chova, A. López Martínez, & I. Candel Torres (Eds.), *ICERI2018 Proceedings 11th annual International Conference of Education, Research and Innovation* (pp. 7663–7671). Seville, Spain: IATED Academy. doi: 10.21125/iceri.2018.0376

Neves, A. G., Dias, D., Duarte, E. & Ramalho, J. (2019). Back to the Basic of Basic Design: The Portuguese Scenario. Em L. Gómez Chova, A. López Martínez, & I. Candel Torres (Eds.), *ICERI2019, 12th annual International Conference of Education, Research and Innovation* (pp. 416–425). Seville, Spain: IATED Academy. doi: 10.21125/iceri.2019.0139

Neves, A. G., Duarte, E. & Dias, D. (2019). Micro influence of Learning Outcomes in Basic Design. Em E. Duarte & C. Rosa (Eds.), *Proceedings of the UNIDCOM 10th International Conference* (pp. 26-36). Edições IADE, Universidade Europeia. http://senses2019.unidcom-iade.pt/wp-content/uploads/2020/12/Proceedings-of-the-10th-International-Conference-SensesSensibility-2019-Lost-in-Glocalization-final-version_medium.pdf

Neves, A.G., Duarte, E. & Dias, D. (2019). Traçando o percurso do Design Básico no IADE. *ErgodesignHCI*, 7(1), 66-81. doi: 10.22570/ergodesignhci.v7i1.1006

Neves, A., Ayanoglu, H., Goncalves, E., Dias, D., Duarte, E. (2022). Anticipating the Impact of Virtual Reality for Learning the Design Fundamentals: Students' Perceptions and Perspectives. In: Daniel Raposo, Nuno Martins and Daniel Brandão (eds) Human Dynamics and Design for the Development of Contemporary Societies. AHFE (2022) International Conference. AHFE Open Access, vol 25. AHFE International, USA. http://doi.org/10.54941/ahfe1001404