Fernando Galdon[a]* and Ashley Hall[b]

[a] *Global Innovation Design, Royal College of Art, London, UK*

[b] *Design Research, Royal College of Art, London, UK*

fernando.galdon@network.rca.ac.uk

About the Authors:

Fernando Galdon: Fernando is a Ph.D. candidate and is pursuing a doctoral programme in Global Innovation Design at the Royal college of Art, where he is investigating the design of trust at the intersection of Artificial Intelligence and society.

Ashley Hall: Ashley is Professor of Design Innovation at the Royal College of Art where he leads postgraduate research for the design school and the MRes in Healthcare Design. Ashley researches innovation methods, experimental design, design for safety, design pedagogy, globalisation design and cultural transfer.

The ontological nature of design: Prospecting new futures through probabilistic knowledge

As design thinking evolves we are beginning to develop a clearer idea of its relationship to other domains of thinking and in particular its specific ontological nature. Here we consider design's special relationship to the future and how concepts of anticipation, probabilism and prospectivity underpin a new understanding of design's relationship to cross-domain collaboration potential. In effect we discuss how design cares for the future of transformation in an era where rapidly advancing technologies via exponential technological developments are challenging human-machine interactions. Probabilistic knowledge emerges as an ontological reality for addressing the intrinsically abductive nature of future design research. Ultimately this approach implies a different form of knowing and aims to position design research as the discipline better prepared for addressing the future.

Keywords: Ontology; design research; probabilistic design; prospective design, anticipatory design; design futures

1.0 Introduction

1.1 The ontology of design

Design approaches have been compared to and categorised among the sciences, arts and humanities. For instance, Snow (1959) defined the separation of the domains of knowledge into the sciences and arts and humanities. However, the design discipline can be seen as having its own distinct way of understanding the world. In classic Greece, Aristotle classified knowledge into three categories: the theoretical, the practical and the productive (Atwill, 2009, pp. 165-166). Therefore, positioning

productive disciplines such as design in its own dedicated practice, distinctive from the aforementioned sciences, arts and humanities. Design's intrinsic approach based on planning, solution-based problem solving, problem shaping, synthesis, preparedness, readiness and appropriateness in the built environment determines a different way of knowing.

In this context, Archer (1978) went some way to proposing design as the third culture of thinking fulfilling Snow's challenge to 'fill the vacant plot'. Cross developed this further in his seminal paper *Designerly ways of knowing* building on Archer's work at the Royal College of Art. He describes a third culture as:

'…the collected experience of the material culture, and the collected body of experience, skill and understanding embodied in the arts of planning, inventing, making and doing'. (Cross, 1982, p. 221)

In the process, Cross differentiated design from the sciences and humanities by comparing the terms of different kinds of phenomena studied in the three cultures; the sciences focus on the natural world, the humanities on human experience and design on the man-made world. He also differentiated among the appropriate methods to approach each 'culture'. The sciences use controlled experiments, classification and analysis, while the humanities use analogy, metaphor, criticism and evaluation, finally, design uses modelling, pattern-formation and synthesis.

In terms of the values of each culture, the sciences aim for: objectivity, rationality, neutrality, and a concern for 'truth', whereas, in the humanities the aim is

for: subjectivity, imagination, commitment, and a concern for ‘justice’. Finally, in design practitioners aim for: practicality, ingenuity, empathy, and a concern for ‘appropriateness’ (Cross, 1982, pp. 221-222).

Archer proposed design as a third way of knowing in 1978, however, this proposition was previously presented by Aristotle in the form of productive knowledge in several works (Physics, Nicomachean Ethics, Rhetoric and Metaphysics) more than two thousand years earlier. Productive knowledge is defined by Aristotle as "identical with a state of capacity to make, involving a true course of reasoning" (Nicomachean Ethics 1140a10-16). In this type of knowledge, the "origin" resides "in the maker and not in the thing made” (Nicomachean Ethics 1140a10-16). Like practical knowledge, prospective knowledge deals with what can be "otherwise". However, practical and productive knowledge have different goals.

In practical activities such as ethics, politics or art, goals are directed toward the end. Whereas, productive practices are directed towards means, and knowledge is neither in the user, nor the producer. In this paradigm, neither of them is capable of determining productive knowledge (Nicomachean Ethics 1140a11-13). It is defined by an act of exchange (Metaphysics 1033a24-26). Which always redefines the subjects involved by effecting a shift in power and status. This type of knowledge resides in its transformational capabilities. It is concerned with competing standards of value rather than securing boundaries of knowledge. Its ontology is indeterminate as it is based on potentialities or alternative possibilities (Rhetoric 47;7357a4-5). Things that can be otherwise. It cannot transcend time as it depends on time, circumstances and contexts, therefore past, present and future exist. Knowledge is always “outside itself” residing

not in the “product” but in the use made by a receiver or audience. It is defined by an act of exchange. It has no external arbiter and no final judge. Only users and makers who change with exchange. It is transformational in nature.

This lack of historical research beyond design may have prevented Cross from proposing why there is a dichotomy among scientific and humanistic knowledge and why design, as an embodiment of productive knowledge has been out of the picture. Atwill, building on Ball’s (1977) critique of theory/practise opposition argues that in the 19th and 20th centuries the “post-enlightenment perspective of knowledge fostered the binary opposition of theory and practice, which only further obscures the place of Aristotle’s (productive) knowledge” (Atwill, 1998, p. 163)

Additional contemporary arguments can be found in Lawson differences among scientist and designers/architects;

> “the scientists focused their attention on discovering the rule, the architects were obsessed with achieving the desired result. The scientists adopted a generally problem-focused strategy and the architects a solution-focused strategy.” (Cross, 1982 p. 223)

In this context, the scientist does not have a client and architects cannot work without a client. As described by Aristotle; knowledge is in the exchange and not at the end result. Furthermore, the designer’s role demands to ‘go beyond’ what already exist. This ontological demand differs significantly from science. Building from Levin:

> "The designer knows (consciously or unconsciously) that some ingredient must be added to the information that he already has in order that he may arrive at a unique solution. This knowledge is in itself not enough in design problems, of course. He has to look for the extra ingredient, and he uses his powers of conjecture and original thought to do so". (Cross, 1982 p.224)

Another fundamental element that is missing in Cross's analysis is its temporality or timeframe interventional positioning. In this area John Chris Jones, one of the first design science theorists postulated in his seminal book *Design Method* that design was different from the arts, sciences and mathematics. In response to the question 'Is designing an art, a science or a form of mathematics?' Jones responded:

> "The main point of difference is that of timing. Both artists and scientists operate on the physical world as it exists in the present (whether it is real or symbolic), while mathematicians operate on abstract relationships that are independent of historical time. Designers, on the other hand, are forever bound to treat as real that which exists only in an imagined future and have to specify ways in which the foreseen thing can be made to exist." (Jones, 1992. p. 10)

From these perspectives we could position design as a prospective thinking activity in the context of abductive reasoning (making decisions without having all the information). In this area research by Dorst (2011) or more recently Cramer-Petersen *et al*. (2018) have concluded that design combines deductive and abductive reasoning,

however in both cases abductive reasoning plays a fundamental role as the initiator of design activity. Without abductive reasoning there cannot be deductive as there would not be anything to reason from. Furthermore, as the digital paradigm with its exponential development and network uncertainty will become more prevalent for design and research, researchers will need to focus more on the preventive and prospective aspects of design (preparedness, readiness and appropriateness). In this context, the deductive becomes limited by access and abductive reasoning aspects becomes more dominant, prevalent and necessary.

Design's intrinsic prospective approach, based on planning, solution-based problem solving, problem shaping, synthesis, preparedness, readiness and appropriateness in the built environment determines a different manner of knowing. In this scenario the designer is neither a scientist nor a sociologist as they are projecting what is yet to be known. Therefore, knowledge cannot be empirical nor observational, but as Aristotle stated; transformational. Consequently, its output is based on potentialities not certainties. In the same way that anthropology is not about facts, but approximations which are updated as new information emerges. As Glanville proposed, 'knowledge for' future action and transformations rather than 'knowledge of' past actions and events (Glanville, 2005). This position connects to John Chris Jones's statement above (1992. p. 10). In this context, as the life of the intervention is placed into the future, the time to assess the impact of the design is extended during its lifetime and forever bounded to its environment. In this context, validation is always a posteriori, and the proposed output becomes the main element to be assessed. This intrinsically argues that knowledge in design is probabilistic in its nature.

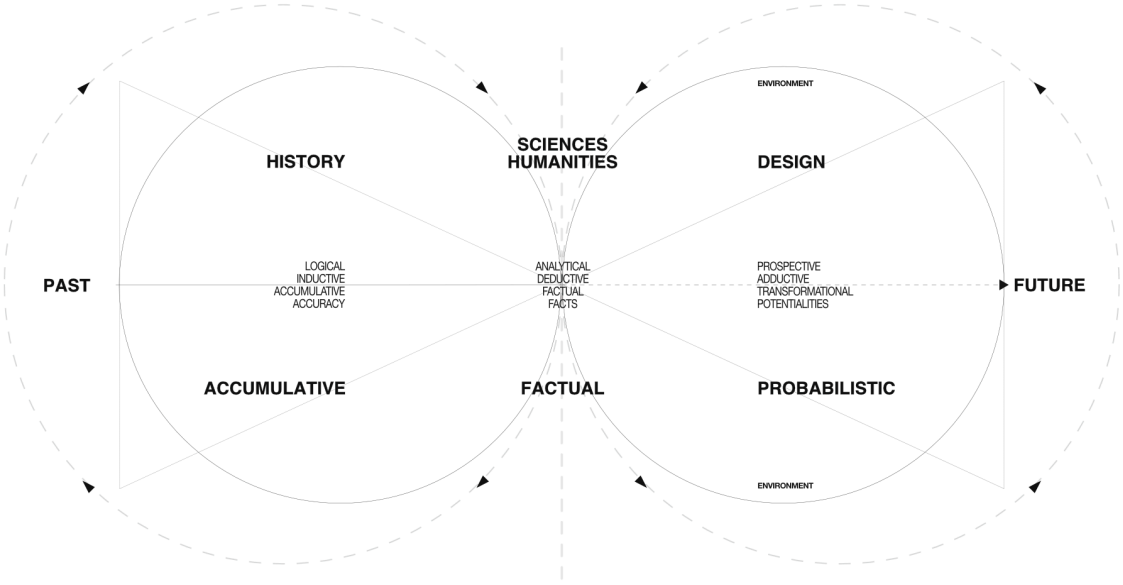

Figure 1. Knowledge and time. Fernando Galdon (Galdon, 2019).

This argument is extended and explored in three applied examples of a prospective nature in the forms of actions, practice and products that demonstrate probabilistic future knowledge aimed at underpinning a proposed new framework.

2.0 Method

2.1 Examples

2.1.1 Prospective Actions

Recently, due to emerging technologies transforming the future of our cities, the Swedish government decided to investigate future housing typologies. They selected a plot of land and invited a range of architects to present proposals for addressing the rising concerns around sustainability and mobility. Some of these proposals were completed by 2018 (Mallet, 2018). The experiment was finished however we do not know whether these new typologies are adequate or not as we need to wait another 10

years to find out. As proposed by Aristotle, productive knowledge is defined by an act of exchange.

2.1.2 Prospective Practices

In fashion, once a collection is presented, designers start to prepare their next collection. In this context, first they research potentialities; colours, fabrics, new materials, culture, etc. From these referential points, they must generate ideas (vision), then design ideas are created (technical aspects of making), and finally these ideas are presented to the public (show). The designers must develop this process without fully knowing how the world will be. They start a collection in September which will be presented in February, yet will be bought by consumers in the following September. At the time of the presentation when 'the experiment' is finished they will know if the designs have been technically well constructed, but will not know whether or not they will be successfully adopted in the marketplace. They need to wait some months to know whether they were the right designs or not. And they will be able to assess them by the level of exchange generated.

2.1.3 Prospective Products

In term of technology, another case can be illustrated by the iPhone. When the design is finished we know if the camera works, whether it creates photos with the right amount of pixels, whether the GPS is accurate or whether or not it is ergonomic. However, we do not know whether the iPhone will change future social and economical factors in 2 years time. The iPhone X is better in many ways than any predecessors as it has a better camera, better screen, better sensors and better software Etc. However, it is

not being adopted at the same rate as previous versions were. A posteriori social, economical and environmental factors affect the exchange mechanism. As proposed by Aristotle, productive knowledge is defined by an act of exchange.

2.2 Critical analysis

The iPhone is a paradigmatic case to understand how we are grasping the a posteriori impact of design as time evolves. In the first 2 years we discovered that it had transformed the mobile industry. After 5 years we discovered that it had transformed the manufacturing system. Over 10 years, we are discovering that it has transformed society. Scientific extrapolations could never have predicted the social implications of having a tracking device in your pocket capable of monitoring everything you do and everywhere you go and use this information to manipulate society, trends, markets and beliefs. Neither science nor sociology could approach this a posteriori reality as they are limited by what we do and have done and how we have achieved it. In other word an ontology of the past. As Glanville suggested, we are limited by knowledge of the past (Glanville, 2005). However, the intrinsic prospective approach of design, based on planning, solution-based problem solving, problem shaping, synthesis, preparedness, readiness and appropriateness can provide a suitable framework to access these future spaces for knowledge.

The same aspects could be drawn from the previous example in government lead prospective transformation to investigate future typologies in cities. Neither scientist nor sociologists can grasp potential developments as they are limited by the present, either by measurement or observation. Yet the government must take action.

Finally, design practises may be understood as practises aiming for personal fulfilment or personal development. However, the authors address the applied nature of these disciplines aiming to go beyond personal transformation to deliver practical interventions to transform society. This implies exchange beyond oneself involving social, economic and environmental activities. This exchange is always a posteriori and forever bounded to its environment. When you finish a fashion collection, or an iPhone, or a house, or a song, or a theatre play, or a movie, or a book, or an app, you do not know whether it will transform society or not. It will be known a posteriori and will be valued based on whether there is exchange or not. Therefore, design is a prospective activity and knowledge in design is probabilistic in nature.

These examples present a totally different knowledge, which is radically different from the humanities and sciences observed by CP Snow. As described in the examples presented in this section we may know ‘technical’ aspects; for instance structural or material qualities, or whether they comply with a set of regulations, however we do not know whether these are the right typologies for future living or the social impact they may inflect in some years time. In sociology or science once the experiment is finished we know the answer via measurement or observation. Design is prospective and this implies a probabilistic nature to the knowledge generated as we are dealing with new propositions that evolve in time.

3.0 Discussion

3.1 Design as a method in research

Design research practice emerged as a professionalised activity in the 1960's, where domain thinking was largely dominated by the humanities and the sciences. This 'late arrival' forced designers to adapt design practice through methods from other domains. A good example of this is Bruce Archer's doctorate which attempted to explain design as a special branch of science (but usefully it failed in doing so)(Boyd Davis, 2016). Other examples are critical design, participatory design and social design which could be argued as conducting aspects of social science through design. Even environmental design or engineering design could be thought of as doing science though design. In these cases design is dissolved into a methodological process based activity. If we position design as a data gathering method then we are tying design to the present. These aspects imply the dissolution of design as a discipline into views of the present and prevents it from being recognised as an independent domain. Furthermore it questions the core ontology of design's knowledge base for transforming that which has yet to arrive.

In this context, design becomes secondary and is subjected to other disciplines' rules and mindsets. In this scenario thinking is analytical, reasoning is deduced and knowledge must be factual by means of observation or measurement. In this context abduction is denied. The traditional paradigm positions design as a method within research which creates tensions that arise between the prospective nature of design and the factual requirements of working in the present. There is an ontological problem between the nature of design as future-led and prospective, and the nature of research

which is present-based and factual. We argue that the core nature of design is probabilistic research, not empirically driven research. We trade some degrees of accuracy to access areas yet-to-be or not-fully-formed, therefore our output is probabilistic and research is always preliminary in its nature. Moreover, in exchange we provide guiding knowledge for prospective technological developments; 'knowledge for' instead of 'knowledge of'. We are concerned with how things 'ought to be' (Simon, 1996. p.111-167) instead of how things are.

3.2 Design as a discipline of the future

From this perspective we would position design as a future-led prospective thinking activity in the context of abductive reasoning. In this scenario, as the designer is neither a scientist nor a sociologist (Cross, 1982, p. 221), design cannot be experimental as understood in scientific terms nor observational as understood in sociological terms, but transformational, as Aristotle suggested. (Hall, 20111). Consequently, its output is based on potentialities not certainties. In the same way that anthropology is not about facts, but approximations which are updated as new information emerges. In this context, as the life of the intervention is placed into the future, time to assess the impact of the design is extended during its lifetime. Validation is always a posteriori and the proposed output becomes the main element to be assessed. The validity of the output generated, whether in a commercial or research context will be judged by the transformational impact generated, which is defined by the level of exchange. The function of design is to transform and if the output does not achieve this, it has failed.

This perspective also repositions the role of the designer from a facilitator into an expert in prospecting what could or should be done in the future. It challenges current ideas in the field positioning the designer as an event gatherer, whose main function is to facilitate exchange among experts. By repositioning the designer as an expert of the future, the role of the designer is to sit in the same room with an equal status among experts. To participate and collaborate with them as equals. In this approach the gathering of an event returns to sociological practices and the designer is embraced as a prospective expert whose main duty is to develop and envisage the potential transformations between a knowledge-based technology and future society. This framework does not aim to prevent designers from becoming facilitators or doing sociology through design, rather it aims to provide a new possibility for designers to act as experts and embrace the intrinsic perspective of their true ontological expertise.

3.3 Probabilistic knowledge

However, this future-led proposition presents a problematic situation for the ontology of knowledge, by which the limit is the present and the researcher is the witness, either through measurement or observation. In this area, if we analyse what happens in economics research we may find a suitable framework to solve this conundrum.

Economic forecasting is the process of making predictions about the economy with many institutions such as the International Monetary Fund, World Bank, the Organisation for Economic Cooperation and Development, national governments, central banks, private sector entities, including think-tanks, banks, consultants and

companies use economic forecasting. Economist use statistical analysis of historical data to determine the forecast. Formal forecasts are produced once a year, however, quarterly updates or corrections are implemented to fine-tune the projection. The fundamental function of the economist is to anticipate future risks (i.e., events or conditions that can cause the result to vary from their initial estimates). These forecast are continuously updated as the conditions of the environment evolve. These evolutions determine whether the adjustments will get tighter or looser, how interest rates vary affecting a wide range of factors from loan repayments to employment levels.

At this point a fundamental question arises; is this knowledge? Of course it is knowledge, it is probabilistic knowledge of the future. Based on theses economic forecast international institutions and governments implement all manner of adjustments impacting the lives of millions. From this perspective economics research enables design to access the future by legitimising probabilistic knowledge as a valid type of knowledge. This element provides a bridge to reconcile the probabilistic nature of design with established frameworks of knowledge so far understood as factual.

3.4 The value of probabilistic design knowledge

3.4.1 translational

In 1969 Peter Drucker popularised the ‘knowledge economy’ in his book *The age of discontinuity.* (Drucker, 1969). Some decades later, the ‘Cox review’ established the need for an hybrid model entangling academia, the public and the private sectors (Cox, 2005). One year later, the World Bank presented its Knowledge Economy report and KAM methodology which asserts that sustained investments in education,

innovation, information, communication technologies and a conducive economic and institutional environment will lead to increases in the use and creation of knowledge in economic production, and consequently result in sustained economic growth (Chen, D. H.C.; Dahlman, C. J. 2006). Following this report the Sainsbury review positioned science as the main paradigm in developing the hybrid model. (Sainsbury, 2007). From this perspective a four years translational quarterly pilot project started in Liverpool. It was a project aimed at experimenting with the hybrid system proposed by Cox. Following this experiment, in 2012 a report enhancing the advantages of the pilot was published (Knowledge, 2018). Finally, in 2014 two £1 billion pound projects were announced; Imperial west and UCL East they aimed to scale the Liverpool pilot project.

In this context, what is changing is the productive model, from the production of goods to the production of knowledge. The main element to account for in this paradigm is the translational potentialities of it, in other words, how to transform basic research into social and economical opportunities. Nowadays, the value of research is not in the discovery but in the value and impact it returns to society. In this context sociologists and scientist are struggling when presenting the future translational potentialities of their research and many institutions are moving from fundamental to applied research to fulfil this shift. For instance in sociology, building from the work of Pain, Gregson and Olsen (Pain et al. 2011; Pain, 2014; Gregson et al. 2012; Olssen, 2015) the LSE's Impact Blog explains that "Anxiety around the impact agenda arises from the increasing instrumentalisation of knowledge, the corporatisation of UK higher education, and the relationship between assessment metrics and neoliberalism" As well as "fears that impact will prioritise certain kinds of knowledge" or "there are also

concerns it rewards particular types of researcher" (Marchen, 2018). In a demonstration of the transformational nature of research output and impact, the LSE blog's author argue that instead of building from Pain *et al*.'s emphasis on the "political imperative to restate the kind of academy in which we want to work" (Marchen, 2018). Researchers need to apply participatory action research to address the evolving nature of research (Marchen, 2018). Clearly the translational imperative of the knowledge based economy is starting to affect practices in sociology. In this context cross-disciplinary collaborations among sociologists and designers may enhance the transformational potentialities of sociological enquiry. However, it seems that instead of fostering collaboration, which imply understanding the expertise of designers and treating them as equals, others disciplines are either rejecting the new reality in the research ecosystem or adopting design methodologies as part of their toolkit rather than inserting designers in the research process. For instance, several universities in the sciences such as Stanford, University of Maryland, or Ball State University have been integrating design thinking courses into their curriculums for some time (Morris, 2015). According to Dorst 'Design Thinking' is identified "as an exciting new paradigm for dealing with problems in many professions—most notably IT (e.g., Brooks 2010) and Business (e.g., Martin 2010)" (Dorst, 2011, p.131). If we look at the term in Google trends, we can observe an exponential increase of the term 'design thinking'.

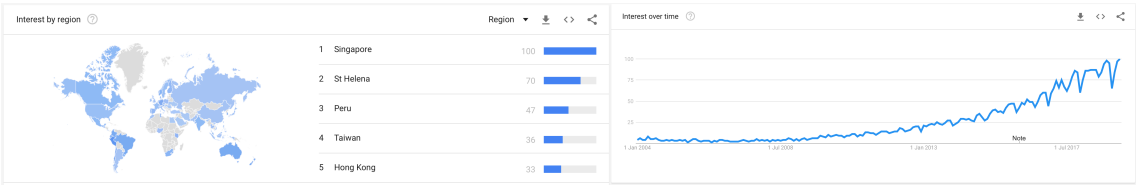

Figure 2. Design thinking evolution. From Google trends.

However as Dorst point out its adoption is much more complex that current simplifications. This reality positions design and designers centre-stage as key partners in knowledge production and translation with an expertise as catalysts for prospective transformations.

3.4.2 Social

As we are completing the transition from the industrial to the digital economy the acceleration of innovation is transforming reality and affecting the development of society. In this context recent strategies in the social sphere call for anticipatory strategies, for instance Guston (2014) introduced the idea of anticipatory governance defining it as "a broad-based capacity extended through society that can act on a variety of inputs to manage emerging knowledge-based technologies while such management is still possible" (Guston, 2014). In this context, design, due to its intrinsic prospective characteristics based on preparedness, readiness and appropriateness, seems the most appropriate partner to deal with the exponential nature of technological development from a prospective and preventive perspective. In this context applied ethics emerge as a fundamental implementation of prospective design.

However, this acknowledgement has been missing in the area of social governance, where traditionally three main methods have been implemented to deal with ethics in technology; technology assessments, ethical quandaries and public engagement. Sheila Jasanoff, professor of ethics and invention at Harvard University provides a critical review of these procedures, and based on an extraordinary amount of

supporting evidence, she states that these processes while interesting are not sufficient to deal with the exponential nature of technological advancement. Her book is a testament of the limitations of sociological methods to address prospective technological development. As a conclusion Jasanoff illustrate "how the power to set the rules of the game for governing technology rests with capital and industry, and not with the political representatives of the working, consuming, and too often suffering masses". (Jasanoff, 2016. p. 266). The future of governance is determined by design and only prospective activities may access those spaces from a proactive perspective. Sociological strategies are reactive in nature, as they limited by the present. Jasanoff's account presents an empirical need to enable a research space to address the rising concerns of technological development from a social perspective. And design prospective ontological nature fulfils this requirement.

Finally, in a report presented by the Institute for the Future on 'anticipatory governance' (Future, 2009) the authors aim for processes that involve the simulation of possible futures to address anticipation as a strategy for good government. In this context the prospective and probabilistic nature of design may contribute significantly to the future development of society supporting anticipatory governance through abductive-prospective thinking.

In this processes we aim to change the directionality of the action; instead of waiting for the anticipation to happen, design allow us to be proactive and move for more imminent future transformations. The role of the prospective research-focused designer is to enhance knowledge-based technological potentialities and reduce future risks.

3.5 From time-based research to prospective interaction research

How do we approach prospective design practice in the knowledge landscape? If we go back to the categorisation of knowledge presented by Aristotle we can observe that he established three main categories; the theoretical, the practical and the productive. Theoretical knowledge encompasses abstract subjects. It is concerned with things that are universal and necessary. Yet that cannot be applied. The idea that theoretical knowledge can never be utilitarian builds on the ancient sense of theoria as observation rather than participation. In contrast, the practical is applied and question based; it has a beginning and an end. Finally the prospective is based on a continuous interaction with the environment. It is transformational and a commitment to practice (Atwill, 1998). Therefore prospective knowledge is defined as a capacity to make involving prospective reasoning to 'go beyond' what exists and propose what can be 'otherwise'.

These assertions and arguments question the reality of the methodological nature of design and confront the practice-based timeframe with a beginning and an end model imposed from the sciences and humanities. The nature of time-based industrial processes of knowledge production and traditional research approaches are affecting the very same nature of these transformations and potentialities.

4.0 Conclusion

We have argued to reposition the origin of design research and place it with an Aristotelian rationale of productive knowledge. This implies that design research has no end in itself as it is always implicated and will remain in exchange. In this scenario design research has no external arbiters and no final judge in the present. In this context neither the user nor the producer is capable of determining prospective knowledge as it is defined by an act of exchange. This exchange always redefines the subjects involved by effecting a shift in power and status through its transformational nature. It cannot transcend time like mathematics and depends on time, contexts and circumstances. Therefore assuming past, present and future timeframes and the impact of the environment changing future social and economical factors. It is instrumental and situated, and its value is social, economic and environmental.

Design research is concerned with competing standards of value rather than securing boundaries of knowledge and its practice is based on the capacity to make new futures involving abductive reasoning. It is concerned with something coming into being indicating that things can be otherwise and beyond themselves as currently configured. It is concerned with indeterminate and possible within alternative possibilities. From passive intellect (contemplation becoming its object) to active intellect (object being defined) to prospective intellect (object being transformational a posteriori through exchange).

In the prospective framework we have proposed design research can access the future, however current models of research are limited by the present either by observation or measurement. In order to address this fundamental aspect we present the concept of probabilistic knowledge by building from new approaches in design and economics. Probabilistic knowledge in the context of design could be defined as the potential impact of transformational initiatives.

The value of design research as presented here is economic and social therefore aiming for mixed methodologies to implement strategies building informed interventions to support planning, solution-based problem solving, problem shaping, synthesis, preparedness and appropriateness in the built environment. These aspects are fundamental for an adequate development of society in an ever evolving world based on exponential technological developments. So far inaccessible due to the present limit framework of sociology or science that can only analyse what already exist. We propose making a contribution to contextualising Glanville's concept of knowledge for transforming the future as a probabilistic knowledge ontology.

This approach reposition the role of the designer from a facilitator to an expert in prospective future-led translational and transformational technological developments to enhance knowledge-based technological potentialities and reduce future risks. In the process reposition multidisciplinary research collaborations from a subject facilitating discussion between experts to being one of the experts in the panel with the same status and role. This prospective nature excludes the designer from being a scientist or a sociologist and prevents design from being experimental or observational (in the

scientific meaning of the term), as the projected potentiality is placed in a society yet-to-be or not-fully-formed. Therefore it cannot be precisely measured or described as it does not fully exist.

5.0 References

Archer, L. B., (1978) Time for a Revolution in Art and Design Education. RCA Papers No. 6. Royal College of Art, London.

Aristotle., (2000). Book VI. In R. Crisp (Ed.), Aristotle: Nicomachean Ethics (Cambridge Texts in the History of Philosophy, pp. 103-118). Cambridge: Cambridge University Press. doi:10.1017/CBO9780511802058.010

Aristotle., (1998). Metaphysics. Translated by Lawson-Tancred, Hugh. Penguin. 1998. ISBN 0140446192.

Aristotle., (1984). Rhetoric. W. Rhys Roberts (tr.). in The Complete Works of Aristotle. Vol. II. Jonathon Barnes (ed.). Princeton, NJ: Princeton University Press.

Atwill, J., (1998). Rhetoric reclaimed: Aristotle and the liberal arts tradition. Ithaca, NY: Cornell University Press.

Ball, T., (1977). Plato and Aristotle: The Unity versus the Autonomy of Theory and Practice. From: Political Theory and Praxis: New Perspectives. pp. 55-70. Minneapolis: University of Minnesota Press.

Boyd Davis, S., Gristwood, S., (2016). The Structure of Design Processes: Ideal and Reality in Bruce Archer's 1968 Doctoral Thesis, Design Research Society, Brighton, June 27-30th 2016

Chen, Derek H.C.; Dahlman, Carl J., (2006). The knowledge economy, the KAM methodology and World Bank operations (English). Washington, DC: World

Bank. http://documents.worldbank.org/curated/en/695211468153873436/The-knowledge-economy-the-KAM-methodology-and-World-Bank-operations

Cox, G., (2005). Cox review of Creativity in Business: building on the UK's strengths. https://webarchive.nationalarchives.gov.uk/20120704143146/http://www.hm-treasury.gov.uk/d/Cox_review-foreword-definition-terms-exec-summary.pdf

Cramer-Petersen, C. L., Christensen, B. T., & Ahmed-Kristensen, S., (2019). Empirically Analysing Design Reasoning Patterns: Abductive-deductive Reasoning Patterns Dominate Design Idea Generation. Design Studies, 60, 39-70. DOI: 10.1016/j.destud.2018.10.001

Cross, N., (1982). Designerly ways of knowing, Design Studies Vol. 3, No. 4 October 1982, pp. 221-227.

Dorst, K., (2011) The Core of "Design Thinking" and Its Application. Design Studies, 32, 521-532. https://doi.org/10.1016/j.destud.2011.07.006

Future, I., (2009). Anticipatory governance. From institute of the future. Retrieved: 12 April 2019. http://www.iftf.org/uploads/media/SR-1272_anticip_govern-1.pdf

Galdon, F., Hall, A. & Wang, S. J. (2019). Prospective design: A future-led mixed-methodology to mitigate unintended consequences. Proceedings of the International Association of Societies of Design Research Conference IASDR2019, The University of Manchester, UK.

Glanville, R., 2005, The Unthinkable Doctorate: Brussels, Design Prepositions. Cybernetics Research. American Society of Cybernetics, UK and Australia

Gregson, N., Watkins, H., Broughton, L., Mackenzie, J., & Shepherd, J. (2011). Building Bridges Through Performance and Decision-making: Schools, Research and Public Engagement. Antipode, 44(2), 343–364. doi:10.1111/j.1467-8330.2010.00839.x

Guston, D. H., (2014). Understanding 'anticipatory governance.' Social Studies of Science, 44(2), 218–242.. https://doi.org/10.1177/0306312713508669.

Hall, A. (2011). Experimental design: Design experimentation. Design Issues, 27(Number 2, Spring 2011), 17-26pp.

Jasanoff, S., (2016). The Ethics of Invention: Technology and the Human Future. New York: W.W. Norton & Company

Liverpool Knowledge quarter, (2018). Bringing the vision to life. Retrieved: 12 March 2019. https://www.kqliverpool.co.uk/pdf/kql_vision.pdf

Levin, P H., (1966). 'Decision making in urban design' Building Research Station Note EN51/66 Building Research Station, Garston, Herts, UK.

Mallet, L., (2018). Creating quality living:the new Swedish town offering innovative solutions to London's housing crisis. Evening standard. https://www.homesandproperty.co.uk/property-news/the-new-swedish-town-offering-innovative-solutions-to-londons-housing-crisis-a116751.html

Marchen, R., (2018). Impact from critical research: what might it look like and what support is required?. LSE Impact Blog. September 4th, 2018. Acceded; 14 March 2019. 18:06. https://blogs.lse.ac.uk/impactofsocialsciences/2018/09/04/impact-from-critical-research-what-might-it-look-like-and-what-support-is-required/

Morris, H. and Warman. G. (2015). Using Design Thinking in Higher Education. Published: Monday, January 12, 2015. Accessed; March, 14, 2019. https://er.educause.edu/articles/2015/1/using-design-thinking-in-higher-education

Olssen, M., (2015). Neoliberal competition in higher education today: research, accountability and impact. British Journal of Sociology of Education, 37(1), 129–148. doi:10.1080/01425692.2015.1100530

Pain, R., Kesby, M., & Askins, K. (2010). Geographies of impact: power, participation and potential. Area, 43(2), 183–188. doi:10.1111/j.1475-4762.2010.00978.x

Pain, Rachel. 1. "Impact: Striking a Blow or Walking Together?". ACME: An International Journal for Critical Geographies 13 (1), 19-23. https://www.acme-journal.org/index.php/acme/article/view/986.

Sainsbury, L. (2007). The Sainsbury review. The Race to the Top; A Review of Government's Science and Innovation Policies. Retrieved: 12 February 2019. http://www.rsc.org/images/sainsbury_review051007_tcm18-103118.pdf

Simon, H. (1996). The Sciences of the Artificial. MIT Press, Cambridge, MA. ISBN 0-262-69191-4

Snow, C. P. (1959). The Two Cultures and Scientific Revolution, New York: Cambridge University Press, 2013.