USING WEB 2.0 TECHNOLOGIES TO FACILITATE THE COLLABORATIVE DESIGN PROCESS AMONG UNDERGRADUATE ENGINEERING STUDENTS: AN ACTOR NETWORK STUDY

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Submitted in fulfilment of the academic requirements for the degree of Philosophy of Education in the School of Science, Mathematics, and Technology Education, Faculty of Education at the University of KwaZulu-Natal, South Africa.

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Declaration

I, the undersigned declare that:

(i) The research reported in this thesis, except where otherwise indicated, is my original work.

(ii) This thesis has not been submitted for any degree or examination at any other university.

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Abstract

In this thesis I am motivated by a keen interest in design collaboration, and a belief that the quality of design interactions could be enhanced by employing a repertoire of the new and emerging collaborative technologies in the design process. In this study I employed actor network theory's (ANT's) methodological and theoretical framework to investigate the use of Web 2.0-facilitated collaborative design by Industrial and Manufacturing Engineering students at the Harare Institute of Technology. In line with ANT, I traced the collaborative design process by following the actors in action (Latour, 2005) when the forces of the network were at work, picking up the traces they left behind to constitute the empirical data for the study. By employing ANT analytical tools the data of the network-tracing activity reveals that the Web 2.0-facilitated collaborative process is an emergent actor network that evolves from associations created among the actors as they negotiate the alignment of interests through a series of translations that occur through moments of problematisation, interessement, enrolment and mobilisation (Callon, 1986b). As the actors went through the moments of translation, various interpretations of the design problem were translated into technical solutions and procedures to be followed in search of a satisfying design solution. The process of achieving agreement (or a stable network) is dependent on the translations that take place among the actors. The analysis shows that Web 2.0-facilitated collaborative design is an emergent process. It is a process that evolves from a translation process, during which a hodgepodge of decisions that cannot wait are taken in a complex, dynamic, fluid and constantly changing environment where actions cannot be planned or predicted in any mechanical way (Akrich, Collan, Latour, & Monaghan, 2002). Therefore, the path that the design process takes cannot be predetermined, but emerges from the network of relations that are created by the actors as they work together to achieve their commonly agreed design goals.

Considering the Web 2.0-facilitated collaborative as an emergent process clearly demonstrated that it does not take place in a step by step way, as depicted by many design models. Instead, the process moves back and forth between different domains as the design problem and solution co-evolve and are continuously up for revision (Downey, 2005; Petersen, 2013). The affordances of Web 2.0 technology supported the messy talk (Iorio, Peschiera, & Taylor, 2011) that was critical to the development of design solutions.

The emergent character of Web 2.0-facilitated collaborative design allows for important theoretical and practical lessons for design educators, to improve the teaching and learning of the collaborative design process. With collaborative design as an emergent process, it is no longer methods alone that produce results, but the reassemblage of the totality of translation that takes place among the actors into a stable network of relationships, and it cannot be taught outside of authentic design projects.

Ethical Clearance

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

17 July 2013

Mr Lockias Chitanana 212561428
School of Education
Edgewood Campus

Protocol reference number: HSS/0449/013D
Project title: Using Web 2.0 technologies to facilitate the collaborative design process among undergraduate Engineering students

Dear Mr Chitanana

Expedited approval

This letter serves to notify you that your application in connection with the above has now been granted full approval.

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach/Methods must be reviewed and approved through an amendment /modification prior to its implementation. In case you have further queries, please quote the above reference number. Please note: Research data should be securely stored in the school/department for a period of 5 years

Best wishes for the successful completion of your research protocol.

Yours faithfully

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Professor U Bob (Chair) and Dr S Singh (Deputy Chair)

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cc Co-Supervisor: Dr D W Govender
cc Academic Leader Research: Dr MN Davids
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What I have black-boxed here as my thesis is in fact a *leaky box* that has been stabilised, albeit momentarily, as an actor network. The translation process in the network was mediated by heterogeneous actors, to whom I am deeply grateful and indebted for their invaluable contributions and support throughout my research journey. This thesis greatly benefitted from their experience and kind feedback. I feel truly privileged for having worked alongside them. The following individuals and organisations are among the conspicuous actors who have allowed this work to reach its fruition.

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Dedication

To my loving, selfless and extremely supportive wife Teclar for affording me the opportunity to fulfil this intellectual expedition by creating a concussive atmosphere for the accomplishment of such an important thing in my life. Even when you were in your hospital bed you urged me on. To my dearest children Perfect Ruramai, Hope Tariro and Elisha Munashe for your invaluable patience, blessings and support during the process of coming up with this thesis. Perfect Ruramai deserves a special mention for your unconditional love and understanding and for taking over the care of your mother, brother and sister when I was away from home.

List of abbreviations

ANT	Actor network theory
CHAT	Cultural-historical activity theory
FGD	Focus group discussion
HIT	Harare Institute of Technology
ICT	Information and communication technology
IME	Industrial and Manufacturing Engineering
ITS	Information Technology Services
LAN	Local area network
OPP	Obligatory passage point
SCOT	Social construction of technology
SNVDS	Social network virtual design studio
STS	Science and technology studies
VDS	Virtual design studio
VoIP	Voice over Internet Protocol

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CHAPTER 1

MAPPING THE TOPOGRAPHY OF THE STUDY

1.1 Introduction

This chapter is a 'Cartesian grid' that maps out the topology of the study. Latour (2005), suggests that actor-network theory (ANT) researchers should act like cartographers. The concept of a Cartesian grid is usually used by topographers to map out the topography of an area or country. During this process the topographer looks for landmarks to assist him or her in tracing the demarcations of the landscape. Latour (2005), compares the metaphor of topography to studies that are concerned with the tracing of networks. As Singh-Pillay (2010, pp. 10-11) points out, "the use of the metaphor of cartography implies that there are no signposts or landmarks available to assist the cartographer in tracing boundaries or networks". This is because as is the practice in cartography the landmarks will naturally emerge through the tracing of networks and associations (Latour, 2005). My reason of using the metaphor of topographer was to illustrate the complexity that is involved in the tracing and assemblage of networks at both the methodological and analytical levels throughout the entire thesis. In other words, I used ANT as both my theoretical framework and a source of inspiration for the methodology I used in carrying out this study.

In this introduction I map out the conceptualisation of design by tracing how it has been viewed in the literature to assemble my basis for arguing for a shift in the way we view Web 2.0-facilitated collaborative design in the field of engineering. This forms the basis from which I go on to map the focus of the study and how I used ANT and its rich terminology to conduct the study, underscoring the need to understand collaborative design as a process that takes place in a 'parliament of things' (Latour, 2008). I also outline the focus of the study, highlighting the need for the particular contribution that this dissertation aspires to make, and describing how this may be effectively achieved through the ANT-inspired study presented in the chapters of this thesis. I conclude the chapter with a brief outline of the chapters that follow.

1.2 Mapping the conceptualisation of design

The engineering design process has been presented in many different models in an attempt to promote some clear understanding of how the process is practised. Generally, through the

progressive development of the various models of engineering design, a consensus has emerged with regard to many of these models exhibiting common basic features (Maffin, 1998). Literature on design history shows that the engineering design process has generally been viewed as a staged process aimed at providing solutions to a problem. Ford and Coulston (2007), for example, define engineering design as a sequence of steps, with iteration, that can be grouped into a process phase involving problem identification, requirements specification and concept generation, and the technical phase which involves the generation of detailed designs, prototyping and construction, system integration, system testing, delivery and acceptance and maintenance and upgrading. Figure 1.1 depicts a typical engineering design process as defined by Ford and Coulston (2007).

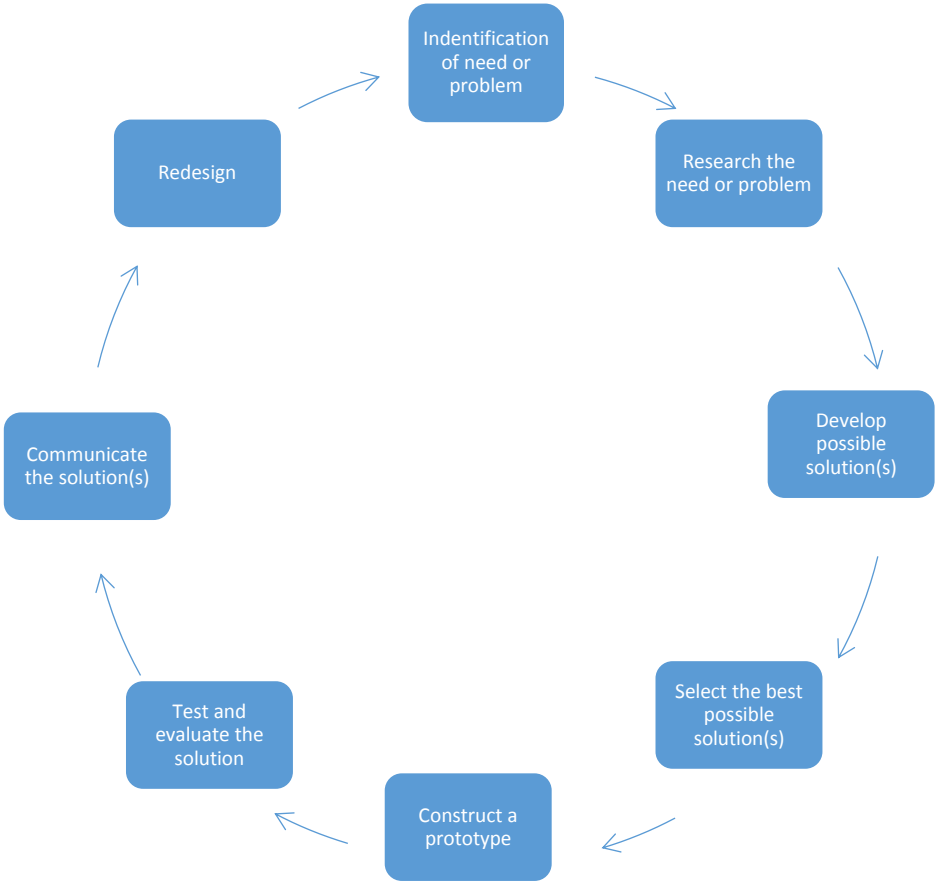

Figure 1: The engineering design process

(Source: Massachusetts Department of Education, 2006, p 84).

Some of the common features of many of the traditional engineering models include the breaking down of the design process into distinct steps that lead to particular intermediate results such as specification of dimensions, preliminary design sketches, functional structure, detailed working drawings and other related documentation (Maffin, 1998). Traditional models subdivide the overall design problem into sub-problems, and put different levels of emphasis

on iteration and interaction within and between the design activities or stages. However, the question I raise in this study is: Are there universal preset stages in a design process? There is a growing amount of literature that questions this positivist stand on the design process. For example, Marples (1960) argues that the stages resulting from the decomposition of the main design problem are only ad hoc sub-problems. Such sub-problems should therefore not be treated as universal but contingent stages (Hatchuel & Weil, 2003).

In practice there has not been widespread acceptance of the rigid traditional design models in many university engineering programmes. This is regardless of the fact that even the proponents of the stage-by-stage linear models acknowledge the need for any design method based on theory to be used flexibly and adapted to the design problem (Maffin, 1998). This is because in practice the nature of engineering design problems hardly ever resemble what is prescribed by these engineering design models. In practice, it has been observed that instead of proceeding from an analysis and problem formulation to articulation of the solution to the design problem in a leaner fashion, the engineering design process in practice often depends on the prevailing situation to propose possible solutions in which problem specification and the design solution creation progress alongside rather than sequentially (Maffin, 1998).

The statement of the problem that this study sought to tackle is aptly put by Hales (1987) when he concluded that:

> (…) despite a long history of innovative engineering design in industry and development of many prescriptive methods and models, the engineering design process is not yet considered well understood or adequately exploited … there is a mismatch between the design process as it is currently modelled in theory and what actually happens in practice.

As a result of the mismatch between the theoretical design models and what obtains in industry, industry has been forced to develop their own procedures to deal with design projects. These approaches to design are based on the overall practical procedures to be adopted in dealing with the design projects, and are usually based on broad organisational concerns rather than the more specific issues of design methodology procedure.

Some methodological concerns have been raised in design history with regards to the authenticity of engineering design models. The major challenge with most of these design models is that they have been developed to focus on resolving structured design problems and

hence represent the most pervasive and general form of design in terms of the variety of possible activities. To be considered complete and coherent, the models needed to be able to deal with design problems in a rational manner, since design was originally conceived as a rational problem-solving process (Simon, 1969). Simon has always claimed that "design theory was nothing else than problem solving theory" (Simon, 1969, p. 11). However, as I have indicated above, most practical engineering design problems are not easily defined; they are in fact ill-structured, indeterminate or 'wicked', such that their definition evolves with the development of the design solution (Maffin, 1998).

During the design process designers normally encounter ill-structured problems which demand them to clarify constraints, define goals and identify existent constrains, which none would have anticipated at the beginning of the design process (Jonassen, 1997). This is because most engineering design problems are complex and ill-structured, such that their organisational patterns are not immediately apparent (Jonassen, 2011). Engineering design problems are different from the natural problems that are solved by scientists; they are artificial problems that emanate from the human-made environment and are thus difficult to explain. Such problems cannot be solved by straightjacket, one size fits all design models. The design process is often intricate, multifarious, and non-linear and is usually unique to the design challenge at hand.

The shift in focus in design theory is coming at a time when developments in information and communication technology (ICT) have taken human interaction to a new dimension. Through relevant ICT tools such as Web 2.0 technologies, collaboration between geographically distributed, multidisciplinary teams has become a standard practice in the world of work. The affordances presented by the various Web 2.0 technologies have made collaborative tasks much easier, as people from different countries can work together online, negotiate and make decisions together. In today's classroom Web 2.0 technologies can be used to create learning environments that can engage learners in authentic collaborative activities that help them develop 21st century skills that emphasise innovation, creativity, collaboration, critical thinking, decision making and problem solving (Zdanytė & O'Connor, 2012). The introduction of Web 2.0 technology into design learning at university level calls for the need to relook at the process of designing with a view to extending our understanding of the process from a networking vantage-point.

The traditional view of design as some work of creativity centred on an individual mental process is rejected by those who view it as a social process. As such there has been a major shift in the way in which design studies, especially those taking the sociological perspective of science, consider design. This is a result of the general shift in sociological perspectives on science, which are no longer accepting the myth of linear scientific progress and its related myth of scientific objectivity and detachment in research methods. In the same way, according to Henderson (1998 p. 139) "design studies are moving away from positivist and functionalist views that prescribe the one 'right way' to do design". The focus in design research has shifted to examination of the diversity of design processes and the acknowledgement of the fact that there is no one right way to carry out design, and no single correct meaning that can be given to the designed artifact in a multicultural society (Buchanan & Margolin, 1995). In actual fact, the positivist views held by design theorists such as Herbert Simon, who have defined design as a science of the artificial, have been challenged by design theorist who view design as the disassembling and reassembling of the parts of nature (Petroski, 1998; Yaneva, 2009).

The most relevant way of viewing design in this study is as suggested by Vitta (1989, p. 31) who sees a design as embracing

> "the totality of disciplines, phenomena, knowledge, analytical instruments and philosophies that the design of useful objects must take into account, in as much as those objects are produced, distributed, and used in the context of economic and social models that are even more complicated and elusive"

By including the whole range of different elements Vitta (1989) comes close to my proposal of design as an actor-network process. The only difference which should not be overlooked is that Vitta is emphasising on the end result rather than the process of coming up with the network. As Buchanan (1992, p. 5) contends, "...design continues to expand in its meanings and connections, revealing unexpected dimensions in practice as well as in understanding". The overall contention that design is an activity defined by the social milieu in which it occurs (Henderson, 1998) is compatible with my proposed view. This view also agrees with the sociologists of technology involved in science and technology studies (STS), who argue that "neither design nor science and technology are value-free"(Henderson, 1998 p. 141). However, my challenges with design research conducted by sociologists of technology which employed the social constructivist framework is that it preoccupies itself with the social interactions among the designers as the most important aspect that shapes the design process and its

solution. One of the most predominant criticisms of SCOT and many other social constructivists is their one-sidedness with respect to their preoccupation with the influence of social relations upon technology, thereby downplaying the influence of technology upon social relations.

As MacKenzie and Wajcman (1999a, p. 44) point out: "it is this mistake to think of technology and society as separate spheres influencing each other: technology and society are mutually constructive". Extended to design this views calls on us to consider design as a process that comprise both the technical and social aspects as having equal influence in shaping the design artifact. A comprehensive view of design should address both aspects. Consequently, progressive design researchers such as Buchanan (1998) discuss the changing character of design, and state the need for diversity and alternative perspectives in creating future visions in order to avoid narrow, rational thinking. There is a need for an open-minded alternative design approach with a wide range of possible outcomes.

1.3 Mapping the focus of the study

In this thesis I am motivated by a keen interest in design collaboration, and a belief that the quality of design interactions could be enhanced by expanding the repertoire of the collaborative technologies in the design process. In this thesis I will develop a perspective and an observational method for assessing design collaboration as it unfolds among engineering students at Harare Institute of Technology (HIT). This emphasises the active role played by Web 2.0 technologies in both human and non-human interactions, and their involvement in the essential aspects of collaborative design. The vehicle for developing this understanding was an open field study of an exemplary Web 2.0-facilitated collaborative design project.

Since the introduction of Web 2.0 technology into design education, a complex design landscape map (Smithers, 2010) has evolved. My argument is that the successful integration of such technology in the design studio is contingent upon, and indeed useless without, an understanding of the socio-technical aspects of the design education environment (Schnabel, 2013). As such, my primary aim for this study is to illuminate the role of Web 2.0 technology as an actor, by exploring the dynamics involved in the collaborative design process as it was carried out by the undergraduate engineering students using various Web 2.0 tools.

My aim is to give an ANT account of the different ways in which students experienced, conceptualised, realised and understood the various aspects of collaborative design (Martin, Détienne, & Lavigne, 2001). However, providing an ANT account of the collaborative design process is not the same as providing explanations for the process (Latour, 1991b, 1996a). Therefore what I intend to do in this thesis is to gain an understanding of the design process as emerging from the translations that take place among actors. Furthermore, I seek to present an insight into collaborative design relational structures and the role played by Web 2.0 technology in shaping the trajectory of the collaborative design process.

Ultimately, I envisaged the study as providing a significant contribution to developing an alternative view about issues which are often overlooked in studies of collaborative design. The outcome should provide a way of extending our knowledge on how Web 2.0 technologies can facilitate collaborative design, and an analytical approach that can inform their more effective use.

In the face of increased usage of Internet-based networking technologies, there is a great need to understand the dynamics of collaboration and the formation of collective commitment in complex socio-technical design environments. Through their ability to create a shared task design working space, in addition to being a vehicle for the substantive participation of key actors in design, Web 2.0 technology has the potential of positively impact the performance of design teams involved in a collaborative design project. Consequently, I concentrated on the exploration of ways in which Web 2.0 technology as a non-human actor mediated the interaction among the heterogeneous actors involved in the design process.

The major aim of this study is to develop an indepth understanding of the development of the collaborative design network and the role played by Web 2.0 technology during the design process through the material semiotic perspective of ANT. The specific objectives of the study are:

1. To document the collaborative design process and observe techniques, strategies and tools used to provide insight into the process.
2. To identify the main socio-technical factors which contribute towards collaborative design network association during the collaborative design process using Web 2.0 tools.

3. To examine how Web 2.0 tools impact the relational tiers between collaborative design actants within a design network.
4. To promote theoretical development of socio-technical collaborative design network assemblages within the field of design.

The specific critical questions of the study are:

1. What Web 2.0 tools are being used by students in their collaborative design activities?
2. How are students using Web 2.0 tools in the collaborative design activities?
3. How do these Web 2.0 tools facilitate the collaborative design process?

To provide answers to these questions I adopt the actor-network theory (ANT) as a new lens that would allow me to explain the assemblage of a design network in Web 2.0 facilitated collaborative design teams. ANT's concept of assemblage is important, because we can view the collaborative design process as an act of assembling and exchanging of knowledge and competencies through a network of actors. As I map the assemblages of the collaborative design network, I develop an indepth understanding of the dynamics involved and the role played by Web 2.0 technology during its assemblage. ANT offers a rich toolkit of resources I could use to develop an analytical lens to examine and illuminate how the design situations unfold during the evolution of the collaboartaive design actor network or how the network emerges through the process of translation.

Accordingly, the methodological rationale that I have developed for this study concerns following and tracing the various complex assemblages of practices, materials and discourse in and through which users are made to matter in collaborative design. In actual fact, I follow Latour (1988c, p. 258)'s guidelines of studying designers in action, focusing on how design networks emerge, become stable and circulate amongst various actors within and beyond the design project environment. In addition, I explore how Web 2.0 mediates the controversy (MacKenzie, 1990b) and uncertainties in order for the actors to align their interests towards achieving the design goals. My tracing of actors also pays attention to how student designers do not succeed in design practice. This is mainly because collaborative design practice involves a (heterogeneous) multiple and fluid cohort of key stakeholders, and this points to the heterogeneity of actors involved in the project. As such, student designers are not the only players in collaborative design.

Accordingly, to apprehend and trace the various forms, competencies and roles of Web 2.0 in design practice, it is necessary to broaden the notion of actors to include more than simply designers as embodied persons. That is to say, actors can also be analytically traced in all the resources that are assembled for the design project within artefacts, in the discursive deployment of rhetorical figures, and in the complexes of data and knowledge that inform and support design practice.

1.4 Mapping the theoretical framework of the study

Generally, where it has been used, ANT has generated substantial controversy as well as fascination across various fields of research, and in design it has also inspired some interesting research. In this thesis I argue that ANT is positioned to enhance our understanding of Web 2.0 design network composition and its development during the collaborative design process. Through its rich methodological and analytical toolkit, ANT has demonstrated the ability to pose problems differently and to provide "rich and risky accounts" (Latour, 2005, p. 133). When employed as a descriptive tool to carry out investigation into how a Web 2.0-facilitated collaborative design process is constituted and carried out in practice, ANT asks us to rethink the traditional notion of design collaboration.

As technology is becoming ubiquitous and pervasive, and design increasingly recognised as a driving force for social change, approaches that allow us to understand the complete dynamics of collaborative design as a heterogeneous network are becoming increasingly important. ANT represents an interesting framework with potential to extend or rethink collaborative design theories and practices in the face of the increased connectivity offered by the new crop of Web 2.0 technologies.

It is critical to the definition of the scope of any engineering project and view that design process is not only a technical endeavour, but also social, a view that has already invaded even the most pure technical domain (Cagan, Kotovsky, & Simon, 2001). The use of ANT as a theoretical lens and methodological framework for this study may cast some light on the ways that the Web 2.0-facilitated collaborative design process is constituted, by illuminating the interrelations between actors. Furthermore, ANT constitutes a relevant analytical tool to explore, map and describe a networked process such as Web 2.0-facilitated collaborative

design processes. ANT is rich in resources that can be used by the researcher to develop a research frame that can allow the researcher to thoroughly scrutinise all aspects of a socio-technical system that are critical in our understanding of the collaborative design process during data analysis. For example, for this study I found ANT's concepts of network, principle of symmetry, principle of performativity, and translation key to my exploration (methodically) and my understanding (analytically) of the Web 2.0-facilitated collaborative design.

First and foremost, ANT offers rich ontological and epistemological insights that could be used to understand the topography of the Web 2.0-facilitated collaborative design process. From its relational ontology and principle of symmetry of entities and their agency, ANT offers a rich toolkit of concepts to look at the relationships between materiality and the social. As such, the dismantling of the generally accepted distinction between human and non-human actors is one of the core issues of ANT. Latour (2005) argues that the conversational dichotomies such as technology-society and nature-culture must be overcome. ANT considers entities and materialities as enacted and relational effects, and seeks to explore the configuration and reconfiguration of those relationships from a flat topology.

ANT includes the non-human actors in the analysis, thereby allowing for a more complete examination of the role of Web 2.0 technology in collaborative design. However, instead of employing a systems approach, as is common in many design researches, Fallan (2010, p. 9) argues that; "ANT uses the metaphor of network to highlight the relational aspect between the nodes, or entities". As such, it is important to note that ANT's expression of network is not necessarily a tangible entity as in the case of a telephone network or sewer systems, nor is it an organisational model. As Latour (2005, pp. 131-132) defines it: "network is a concept, not a thing out there. It is a tool to help describe something, not what is being described (…) it is the traces left by moving agents". In other words, Latour is using the concept of actor network to illuminate how the development and distribution of facts and artefacts takes place through negotiations that take place among different interest groups. In my case, I was interested in exploring and illuminating the network emerging from Web 2.0-facilitated collaborative design.

I employed the principle of performativity as my basis for changing focus from the design product or artefacts to designers' experiences, in order to describe the emerging collaborative design process. The same sentiments are echoed by Faste (1994), who suggests that the

fundamental principle of design is a whole body of experience. Considering that the design process is constituted by what actors do, the focus of analysis shifts from the product or the technology itself to looking at how actors in the design process relate together, and how the various meanings and experiences can be represented in new forms that makes sense. According to Law (1999), the principle of performativity states that entities are performed in, by, and through the relationships in which they are involved. Therefore stability is not an intrinsic quality of a network, but is the result of some deliberate effort by the actors involved. For example, Latour (1986a, p. 273), suggests that society is what is "performed through everyone's efforts to define" or explain it. In other words, society is constituted by the ways in which its elements join together to create and reproduce or alter social patterns. Considering the principle of performativity, ANT would assume collaborative design to be constituted of actors who continuously partake in the process through engaging, mobilising and translating other actors' interests, and finally enrolling others to work towards the achievement of a particular design solution (Latour, 1983).

The concept of translation is one of the central ANT resources that I intended to utilise to describe the Web 2.0-facilitated collaborative design. Translation is a concept that is central to ANT's basic operation and network formation and stabilisation. According to Latour (2005) networks are formed through translation and the systematic alignment of interests. Translation comprises the following four inter-related and overlapping steps that describe how stable actor-networks can be established:

1. Problematisation, whereby the principal actor works to establish itself as an obligatory passage point (OPP) between the network and the actors that it seeks to represent;
2. Interessement, a stage at which actors' interests are stimulated and their terms of their involvement in the actor-network are negotiated. At this stage the focal actor strives to translate the network by convincing the other actors that the roles it has assigned to them are acceptable;
3. Enrolment, a stage at which the actors come to accept the roles that have been defined for them; and, finally,
4. Mobilisation of allies, which involves the focal actor maintaining its crucial position as well as the commitment of the actors it claims to represent.

Furthermore, the process of translation is enforced by the circulation of inscriptions in the actor-network. The circulation of inscriptions also ensures that the focal actor's interests are

protected. Therefore, the concept of inscription is critical for understanding the dynamics of Web 2.0-facilitated collaborative design. The inscriptions introduced by Web 2.0 technology especially in textual form, are crucial in the translation process because they carry meaning which make action possible at a distance. Furthermore, texts and visuals that can be circultated through Web 2.0 present ideas in such a way that their meaning and significance are irrefutable. According to ANT, an actor's ability to circulate inscriptions is crucial and gives some authority and power to the focal actor in the network to direct action in a particular way and direction (Callon, 1987; Latour, 1987b).

The aptness of ANT's concepts of translation for researching complex processes where ICT tools such as Web 2.0 technology are used is well acknowledged (Tatnall, 2009; Walsham, 1997). As my focus in this study is on collaborative design network formation, translation becomes plausible for tracing this network development process. Since translation is the process that is responsible for building stable actor networks, the concept can be used to develop a research frame that can be used to ask how a collaborative design network becomes stabilised. Equally, the failure of the network to become stabilised can be examined by the research frame. I used these moments of translation to present a reasonable approach to understand the evolution of the collaborative design network.

My conception and approach to the design process is constructed by considering the design process as something that has to do with the assemblage of things, including designers, users, different support systems and artefacts – that is, the whole range of actors involved in the process. Applying this approach to design implies that the collaborative design process is constituted by a composition that includes a stream of associations and multiple connections among diverse elements. Such an approach is different from sociological perspectives that begin their analyses with an implicit assumption that society is constituted, or pre-given (Latour, 1999b).

1.5 Mapping the methodology

Since my interest was in studying how designers variously employed Web 2.0 technologies to facilitate the collaborative design processes, I was exclusively concerned with the mutual shaping of technology and the student designers. As such I needed to develop a method that could manage the fuzzy front end (Brun, Steinar, & Gjelsvik, 2009) of collaborative design

that recognises the socio-technical co-evolution of the product and the design process. In this section I provide a preluding note to my methodological choices for this study. As I do that, I make an attempt to ground the reader in the research process I followed in this study, and to anticipate the methodological implications for this study.

ANT is both an analytical framework and a methodology (Latour, 2005). This means that it can be used both as a lens to see the world and as a set of practices, or tools, to describe what the heterogeneity of actors in a network do during their interaction in the network. As I have highlighted earlier on in section 1.3, using ANT as a methodology implies the adoption of some unique methodological principles. The first principle is agnosticism, which suggests that as a researcher I needed to abandon any *a priori* assumptions of the nature of the design network, its causal conditions, or the accuracy of actors' accounts. The second principle is generalised symmetry, which requires me not to privilege humans in my account of the design process, but to employ a single register to analyse human and non-human actors (Tatnall, 2009). The third principle is free association, which advocates abandoning the distinction between natural and social phenomena and the idea that the two are separated by a clear boundary. This imperative meant that my analysis needed to start with no assumptions of any prior socio-technical structures (Law, 1992). In practice this meant that I had to forget about the affordances of Web 2.0 technologies that allow the technology to have an influence on the design process; its influence, if any, is found in the technology's association with other actors as the design process progressed. These three principles informed my ontological and epistemological underpinning that helped me to decide on the most appropriate methods of data collection and analysis.

As a result of the preceding ANT imperatives, I took some bold decisions which were critical for me to provide an ANT account of the Web 2.0-facilitated collaborative design. First and foremost I acknowledged not only the agents of human actors such as the student designers and their lecturers, but also of non-humans such as Web 2.0 technology and the inscriptions that are circulated in a design process. By taking this stand I was able to account for the contribution of all relevant actors, regardless of their nature. Moreover, although ANT has been criticised for unethically and amorally treating humans and non-humans equally (Collins & Yearley, 1992), in design research this has been found to be the missing link in studying complex, interwoven relationships between technology and people in the process (Tatnall, 2009; Walsham, 1997). For me, this allowed me to illuminate the complex and concealed associations

between Web 2.0 technology and other actors, both human and non-human, involved in the collaborative design process.

Methodically, ANT encouraged me to adopt the following ethno-methodological approaches, which are in line with the roots of ANT, to study collaborative design in a Web 2.0 environment, follow the actors (Latour, 2005) and examine inscriptions they produce in their translations. By employing Latour's dictum to 'follow the actors' I had the advantage of multiple vantage points: it made it possible for me to study the collaborative design process from various angles, rather than from the views given by a few privileged actors. In order to understand the associations made among actors in the collaborative design activities there was a need for me to 'follow the actors', both human and non-human, in their translations (Callon & Latour, 1981a). Indeed, material objects are some kind of semiotic incarnation of presumed actors (Akrich, 1995; Woolgar, 1991).

Essentially, this insight implied that in following the actors I did not have to make the *a priori* assumption that actors only exist as human beings. I had to remain impartial as to the various actors that need to be followed (Latour, 1988b, p. 258). Accordingly, in following actors in a collaborative design process and tracing the involvement of these actors, I had to pay attention to the heterogeneity of entities and actors that participated in the design process, including (but not limited to) personas, artefacts, design problem briefs, design sketches, working drawings, computing devices, technology skills, prototypes and user requirements.

Following actors involved following the traces left by the actors and examining closely how actors interacted, negotiated, formed, contested, and broke associations as they sought to align their interests to achieve their design goals. In the case of human actors, it meant letting them talk as I listened to find out the meaning they attached to their actions. In the case of non-human actors, it meant understanding how they exert their agency on other actors and how and who they speak for, as well as what interests and practices they embedded. Thus, following the student designers' practices entailed me studying the alignments of heterogeneous actors that construct collaborative design networks (Michael, 2000).

My following actors also involved collecting relevant inscriptions that provided me with an opportunity to map and examine multiple, complex aspects of the collaborative design process. Inscriptions such as sketches and working drawings are critical in understanding the

collaborative design process because they inscribe practices and decisions as well as speak for the interests and values of the actors involved at points in time. As such, the analysis of inscriptions helped me to illuminate the multiple and complex practices with respect to four aspects: what is inscribed; who inscribes; how it is inscribed; and how powerful it is with regard to what it takes to go against the inscription (Callon, 1991).

Actors had overlaying definitions that come into view during different stages of the design process. Latour (1991b, p. 117) points out that "Contrary to the claims of those who want to hold either the state of technology or that of society constant, it is possible to consider a path of an innovation in which all the actors co-evolve." ANT's principle of generalized symmetry argues researcher to treat both the human and nonhuman actors in a network using the same framework of analysis and according them equal status as actors which can influence the network dyanamics.

The second ANT analytical premise with regard to identifying actors concerns how actors take their form and acquire their attributes by virtue of their relations to other entities. This suggests that not all actors are discrete actors – many are in practice distributed across material and discursive processes. The identity and composition of such actors is therefore a consequence of the associations between entities. At this juncture the epistemological assumption is that actors are not *a priori* human or non-human, material or discursive actors, but rather emerge out of negotiations between those entities involved in the design process. It is these entities which can define the identity and capacities of actors in the design network. As such, in order to understand actors I had to pay attention to the reciprocal relations among everything that was involved in the design process (Akrich, 1992). Furthermore, focus on the relationality of actors draws out another key methodological premise of ANT, namely the principle of generalised symmetry (Callon, 1986c; Latour, 1988b)

1.6 Mapping ANT's terminology

ANT not only offers a unique viewpoint on what there is to know in the world (matters of concern) and how we know it (the tracing of the configuration of effects between humans and non-humans), it also offers a new vocabulary to describe these effects and their components. To be able to trace and map the role played by Web 2.0 technologies in the collaborative design process, I was necessary to first put together the ANT resources I intended to use in the tracing

and mapping of the Web 2.0-faciliated collaborative process. As reflected in the literature review chapter, there are many terms associated with ANT that serve to highlight the key methodological principles for studying actors in collaborative design. However, at this stage I highlight the following terms, which I found to be vital to our understanding of how I deployed ANT in tracing the dynamics of the collaborative design process:

Actor: According to Latour (1997a) p. 10), an actor or actant is, "something that acts, or to which activity is granted by others". In other words, it implies no special motivation of human individual actors or of humans in general. Thus an actant can literally be anything, provided it is granted to be the source of an action.

Network: A network is defined as a "group of unspecified relationships among entities of which the nature itself is undetermined" (Callon, 1993, p. 263).

Node: A node may be an individual, a group, an organization, or a society (Katz, Lazer, & Arrow, 2004). For this study, there were multiple nodes which included the individual student designers, the design groups, the design spaces such as the design studio, the university LAN and the Web 2.0 platform used by student designers.

Translation: This involves the continuous displacement and transformation of actors; where the actors change from who or what they are, to whom or what they want to be or become (Callon, 1986c).

Mobilisation: A network starts to operate to implement the solution proposed, e.g. the student group leader mobilises other students to focus on the design brief (Latour, 2005, p. 16).

Enrolment: This occurs when the principal actor defines the roles that are to be played and the way in which others will relate to one another within the network (Law, 1992); for example, the role of the student team leaders would be defined by their lecturer and they are expected to enrol student designers to participate in the design project.

Enactment: This simply means actors are carrying out the roles that have been assigned to them by the spokesperson of their network.

Mediation: These are actors, both human and nonhuman, who can "transform, translate, distort, and modify the meaning or elements they are supposed to carry" Latour (2005, p. 39).

Interessement: This takes place when the spokesperson locks other actors into their positions, persuading them and putting them in a position where they are ready to carry out their assigned roles (Callon, 1986c). For example, the student leader persuading other student designers to participate in the design project using his/her chosen Web 2.0 technology

Problematisation: This involves the spokesperson of the network defining the nature of the problem at hand and proposing how the problem may be dealt with (Callon, 1986c), e.g. the student leader interprets the design problems as described in the design brief and proposes to work on the design problem in his/her proposed way.

Obligatory passage point: This is a critical network channel established by the spokesperson to ensure that all network communication must pass through the spokesperson' domain, thus making such an actor functionally indispensable to the network (Callon, 1986c).

Intermediary: An actant which only "transports meaning or force without transformation". (Latour, 1987b).

Emergence: This refers to the coming-up of new networks from already clearly defined existing networks (Latour, 1987b).

Convergence: This refers to the alignment of actors in a network, allowing them to agree on common goals and share a common vision on the solution to the problem they are dealing with. (Callon, 1992).

Divergence: This entails a lack of alignment in actors' interests and views about the problem they are dealing with in their network (Callon, 1992).

Uncertainty: This refers to a lack of clarity on who or what makes actors in a network act. This is because action in a network is not always a result of an actor's full consciousness or intensions because there are many other hidden or behind the scenes, agents that will be acting together with them in their action (Latour, 2005).

1.7 The structure of the thesis

This thesis is organised into seven major chapters, as illustrated in Figure 1.1 below. In the first chapter I start off with an introduction to the area of interest, which includes a definition of what I consider to be the problematic area, with some complementary statements by other researchers in the same field. Chapter 2 has three parts: in the first part (A) I introduce my theoretical lens, the ANT, explore what this theory entails and highlight its rich resources, which I used to draw up a theoretical framework that I used to guide the methodological and analytical approaches I employed in the study. In part B I follow the traces of how design has been conceptualised over the years as I try to reassemble a new conception of design from an ANT perspective. In the third section of the literature review, part C, I try to assemble from literature an ANT conception of Web 2.0 and explore how the emerging social networking

technology has been used to enhance the teaching and learning of collaborative design in design-related areas of study like engineering and architecture, for example. I analyse and contextualise the literature on the collaborative design process in order to distill some ANT basis upon which I based my methodological approach to studying Web 2.0-facilitated collaborative design.

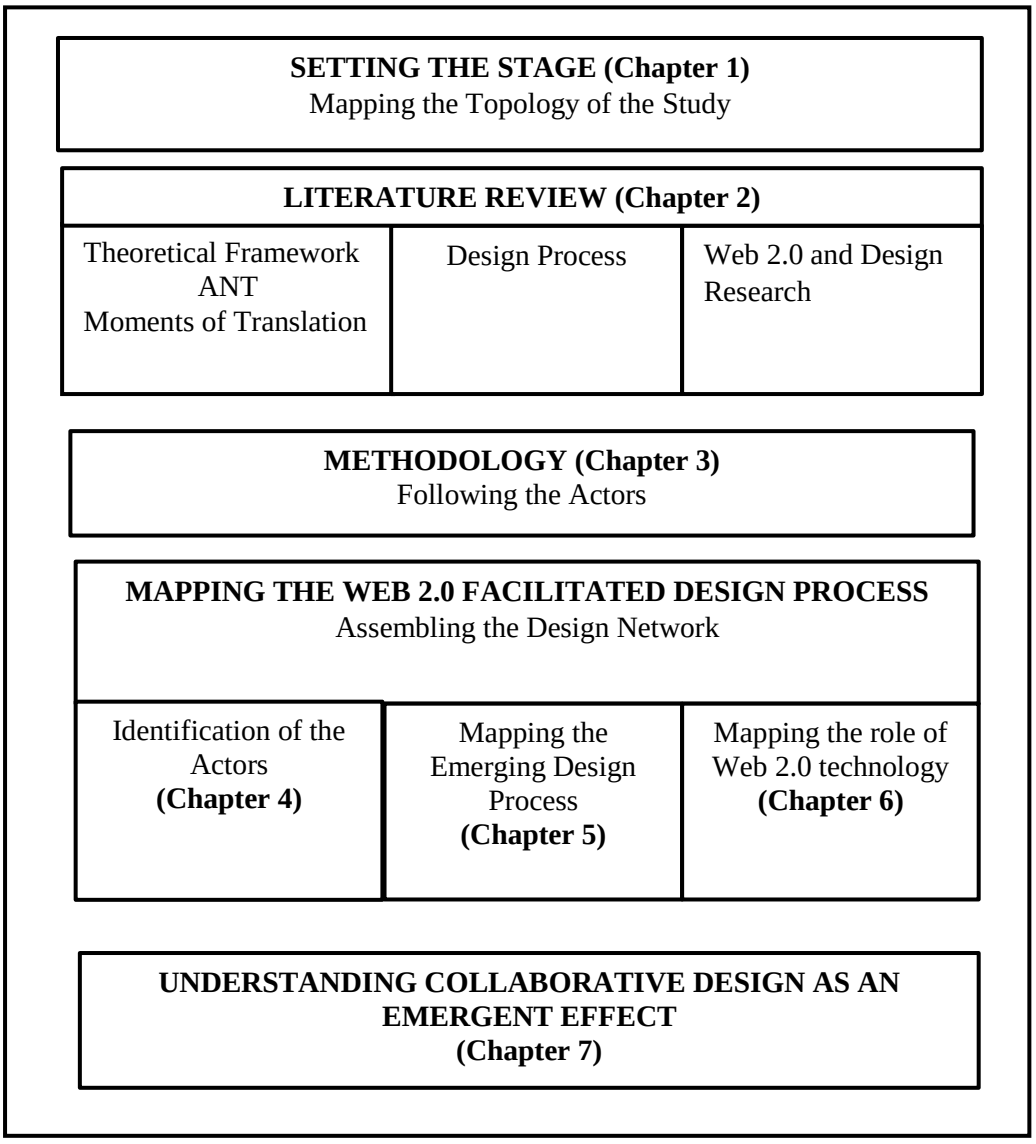

Figure 2: An overview of the organisation of the thesis

In Chapter 3, I provide a detailed account of how I used the various ANT resources to assemble a research methodology to follow the actors during the Web 2.0-facilitated collaborative design. I elaborate on the ANT-inspired framework, highlighting the main methodological insights I gleaned from relevant resources from the ANT toolkit. This equipped me with an empirical approach for exploring and understanding the enactment of Web 2.0 technologies

during collaborative design practices. These insights also set out the necessity of approaching the analysis of the practices of designers and their synthesis of heterogeneous resources, requiring some form of ethnographic methodological assemblage. I used an ANT approach of following the actors, picking up the traces they left during the collaborative design process. In sum, this chapter establishes a means for approaching Web 2.0 technology-facilitated collaborative design as an actor network.

Chapter 4 is the first of three chapters where I present the findings of the study. In this chapter my analysis focuses on the traces that were left by the actors during the collaborative design process, and the assemblage of heterogeneous elements of the design process to establish how Web 2.0 technologies were used as mediators or intermediates during it. The major objective was to identify both the conspicuous and inconspicuous actors, both human and non-human, as well as assembling the various networks that they created at each of the three nodes of the collaborative design process, namely the design studio, the university local area network (LAN) and the Web 2.0 design space.

In Chapter 5 I carry out a cross-nodal analysis of the data to illuminate the translations that took place among the actors, in order to map out how the collaborative design process was constituted. I trace the multiple forms of associations that were formed by the heterogeneous actors across the three nodes, since it is through these associations that the collaborative design process was constituted. I also present findings which relate to the nature of controversies that the actors encountered and the way they used Web 2.0 to deal with these.

In Chapter 6 I present the findings that map the mediation role played by the Web 2.0 technology used during the collaborative design process. There is a predominance of vocabulary for understanding the role of artefacts in society that is offered by ANT. Latour (2005, p.34), one of the proponents of ANT, maintains that the social sciences' exclusive focus on humans should be abandoned in favour of what he calls the "principle of symmetry", which entails that humans and non-human entities should be studied symmetrically. Latour (2005) argues that no *a priori* distinctions should be made between the human and non-human elements if we are to understand what is actually happening in society. Latour (2005) thus argues that not only humans but also non-humans, or conjunctions of humans and non-humans, should be understood as actors.

Finally, Chapter 7 is about the theorisation of the findings. In this chapter I use ANT resources to illuminate the findings of the study in an endeavour to illustrate the contribution of the study to the knowledge of collaborative design from three standpoints, namely theoretical, contextual and methodological perspectives. From an ANT perspective, I demonstrate the Web 2.0-facilitated design process as an emergent process, constituted by a myriad of associations among both human and non-human actors. I also demonstrate that Web 2.0 technologies do not comprise simple intermediaries that are only used to transmit design ideas, but are full actors that mediate and shape the way collaborative design is constituted and carried out in practice. Through their agency they influence how the collaborative design process emerges from the actions enacted by the actors involved in the design network.

1.8 Summary

In this chapter I assumed the role of a cartographer to map the topography for the study. The major issue raised in this chapter is the inadequacy of the current theoretical frameworks to fully explain the complexity of collaborative design in ways that can help design educators to prepare effective designers in the area of engineering.

I set the stage by raising the critical questions of the study. I propose ANT as a theoretical basis that is positioned to enhance our understanding of Web 2.0 design network composition and its development during the collaborative design process, through its rich methodological and analytical toolkit. I also gave a brief overview of how I could use ANT's rich ontological and epistemological insights to draw up a methodological framework that could be used to understand the topography of the Web 2.0-facilitated collaborative design process.

The next chapter presents the literature that I explored to shed some light on the issues that were core to this study, namely the distinctive tenets of ANT, the conception of the concept of design, and understanding Web 2.0 technology from an ANT perspective.

CHAPTER 2

LITERATURE REVIEW AND A SEARCH FOR A THEORETICAL FRAMEWORK

A prelude to the chapter

This chapter comprises three parts: Part A concentrates on the theoretical terrain, Part B traces the evolution of the theoretical conception of design, and Part C considers literature on Web 2.0 technology and ANT design research. The parts are written with the intention of assembling and dissembling the selected ANT books and journal articles in as far as they relate to the design process, investigating their theoretical construction as a way of trying to find my entry-point into an inquiry of the role of Web 2.0 technology in the collaborative design process. As such, I constructed the chapter by negotiating with literature sources including books, seminal papers, journal articles, academic critiques and white papers, as actors in the building of the literature review chapter, uncovering the convergences and divergences that exist among them.

It is my intention to be an actor in this negotiation process and to contribute to the field, following their arguments, weaving through things they have added to the knowledge on collaborative design, so as to render more durable the constantly shifting conception of design knowledge. However, I acknowledge that whatever level of stability in knowledge about collaborative design I am going to achieve can only be considered as a 'leaky box', since the stability will only be temporary. The box will be subject to opening by further researchers, who can work to reassemble it as they endeavour to come up with new knowledge.

The chapter is in three parts, that is, Part A, B and C. In Part A I map the theoretical framework that could be used to examine the trajectory of the Web 2.0-facilitated design. I introduce ANT and its resources as a framework that could be used to carry out design research in a networked environment. In Part B, I explore literature how design has been conceived and highlight the need for change in the way we view design in a networked environment. In Part C, I illuminate the connection between Web 2.0 technology and collaborative design showing how we can use ANT to bring the two together, in a way that helps us develop a new way of viewing design.

PART A: A SEARCH FOR A THEORETICAL FRAMEWORK

2.1Introduction

The objective of this part of my literature review is to map out the theoretical framework for this study. For me to effectively study collaborative design that is facilitated by Web 2.0 technologies, I required a theoretical framework that would allow me to trace the shifting trajectory over multiple sites while placing the social under erasure (Latour, 2005). ANT, as explained by Latour (1987b, 2005), Callon, Law, and Rip (1986) and Law (2007), was a framework that satisfied this criterion theoretically, methodically and analytically. Therefore I discuss how ANT could be used to examine the trajectory of the traces left by student designers and other actors that are enrolled into the design process, since every actor leaves a footprint; this could provide me with insights into the underlying aspects of the collaborative design process. I believe that the ANT methodology offers a number of advantages for studying collaborative design:

(1) ANT researchers are encouraged to follow the actors, which must be done to really understand what happens in collaborative design. In other words, what happens has to be accounted for step-by-step and association by association through the performances of actors, and not presumed based on rarified and perhaps quite wrong presumptions about collaborative design viewed superficially (Bryson, Crosby, & Bryson, 2009);

(2) following the actors helps reveal how inclusive, participative or democratic the process was;

(3) ANT encourages researchers to treat as real the possible associations among design ideas and their proposers, as when design solution options are being discussed; and also to treat as real what is actually decided regarding the options to pursue. Thus, ANT treats as real both matters of concern (issues, possibilities) and matters of fact (agreed actions, decisions) (Bryson et al., 2009); and

(4) ANT is one of the only theories available that would allow the various artefacts produced during the design process to be taken seriously as mediators and actors (Bryson et al., 2009).

According to Feldman and Pentland (2008, p. 306), ANT based research designs "help account for how the ostensive aspects of any set of associations are produced, become stabilised and legitimised, or change, through strengthening or weakening associations respectively." Therefore, ANT based research approaches should seek to define effective research procedures for assembling or composing the collective. Such approaches, therefore have something very

important to contribute to the study Web 2.0- facilitated collaborative design, since these studies also seek to identify the best approaches for assembling or composing the collective through the engagement of those who are involved or have some partial responsibility to carry out during the collaborative design process (Bryson et al., 2009).

I start with a reflection on the challenges I encountered in my search for a theoretical framework (section 2.2). I follow this up by giving a brief introduction to ANT, highlighting what I think the most useful ANT resources are for the purposes of studying collaborative design. I elucidate the distinctive tenets of ANT, paying attention to the unique vocabulary of ANT (viz. actor, action, agency, actor network, association and translation). Furthermore, I unveil the theoretical implications of these terms, because they are indispensable in the tracing (Chapter 3: Methodology) and assemblage (Chapter 4: Analysis) of the collaborative networks.

Studies that employ ANT as their theoretical framework are preoccupied with the resolution of five uncertainties, which are discussed in section 2.4. After this I propose a specific framework for the application of ANT to collaborative design research problems. Finally, I reflect on the framework itself and the way it can change how we can understand the collaborative design process.

2.1.1 The search for a theoretical framework

The focus of this study was to highlight the socio-technical dynamics involved in collaborative design network assemblages that took place among engineering design students. This is a complex process, and finding a theoretical framework that could be used to trace collaborative design in action was not an easy task. A theoretical framework was needed to address the research questions which I generated. In particular, the theoretical framework needed to enable me to do the following:

- Approach collaborative design in terms of a networked activity;
- Trace how the Web 2.0-facilitated collaborative process is constituted and enacted in practice;
- Trace and assemble the associations created by the actors, in order to understand the role played by Web 2.0 technology; and
- Allow both human and non-human actors to account for their actions their networks.

The search for a theoretical framework that would allow me to carry out the task at hand, as discussed above, involved exploration of the following theories: cultural-historical activity theory (CHAT), social construction of technology (SCOT) (Pinch & Bijker, 1984), network theory (Scott, 1994), and connectivism theory (Siemens, 2004). However, a closer look at each of these exposed their inadequacies in resolving the critical issues of this study.

For example, in CHAT (Engeström, 1987; Leontiev, 1978; Vygotsky, 1981), which has been a visible landmark of the theoretical landscape of human-computer interaction, takes up Hegel's and Marx's concept of work as an important starting point. CHAT understands work as a prototype of creative activity mediated by tools and cultural artefacts, and as a process in which humans simultaneously create both themselves and their material culture. Its basic unit of analysis is an activity. The object-orientedness of CHAT in the way it views the subject-object relationship, which bears some similarity to phenomenology's notion of "intentionality" (Dourish, 2001), is the major issue with regard to the appropriateness of the theory in assisting in this research. A closer look at CHAT reveals that the role of context in understanding the activity is critical, because all activity is shaped by the already existing context within which it occurs (Bertelsen & Boedker, 2003). To understand human activity research must therefore focus upon the social, cultural, and historical contexts where meaning is shared and co-constructed with others. Thus CHAT gives special consideration the already existing context to explain the activity, and as a result it does not allow the actors to create the context that shapes the activity. As such, this theory cannot be used to adequately describe the Web 2.0-facilitated collaborative design process and the translations involved since the context in which it takes place cannot be accurately predicted prior to action.

According to Scott (1994) the network theory is a humanistic theory that places emphasis on the social relationships among actors at different nodes of a network. In order to work as an analytical tool it would confine the researcher to humans, disregarding other players in a network. If we view collaborative design as a network, then the network theory would disregard other important actors in the network such as the Web 2.0 tools used, design tools, the LAN, Internet connectivity, and the design studio, among others. However, from a network theory perspective Wellman and Berkowitz (1988) point us to the fact that the concept of node is rather confined to humans and cannot be extended to structures such as the university LAN, the Internet (Web 2.0 virtual work spaces) and the design studio. Nevertheless, in order for us

to fully understand the dynamics of collaborative design these elements cannot be left out. It is for this reason that this theoretical framework could not be used in this study.

One of the most widespread criticisms leveled against SCOT is that it is one-sided; it is mainly concerned with the influence of social relations upon technology and underestimates the influence of technology on social relations. In other words, the theory is accused of seeking to more or less replace technological determinism with social determinism. The theory has also been considered incompetent at dealing with the materiality of artefacts; in actual fact it "denies the obduracy of objects and assumes that only people can have the status of actors" (Akrich, 1992, p. 206). As such, SCOT looks for relatively stable social groups to explain the meanings ascribed to technical objects. In doing so SCOT maintains the duality of the social and the material or the social and the non-social in describing the relationship we have with technology. SCOT tends to privilege the social in its explanations of phenomena. In order for us to have a full understanding of the influence of Web 2.0 on collaborative design, neither technology (Web 2.0) nor the social order should be given privilege over the other.

As MacKenzie and Wajcman (1999b, p. 44) point out, "it is this mistake to think of technology and society as separate spheres influencing each other: technology and society are mutually constructive". The ANT can be viewed as one way to create a theoretical framework that is better suited to articulate this. In any case, in engineering the point is that design artefacts are developed as a result of negotiations that take place between the various actors involved, each with their different interests, agendas, needs and desires (Fallan, 2008a). To design researchers this implies that artefacts are viewed as products of science and technology and scientific theories and technological objects. Central to ANT is the desire to treat entities and materialities as enacted and relational effects. ANT therefore seeks to explore the configuration and reconfiguration of those relationships (Law, 2004). In its description of these relationships, ANT disassembles the conversational dichotomies of technology-society and nature-culture, thus in some way dismantling the axiomatic distinction between human and non-human actors in a network of things. I will return to this unconventional outlook later on in this chapter, but first ANT needs a closer look.

2.1.2 A brief overview of ANT

I settled on ANT, as explained by Callon et al. (1986); Latour (1987b, 2005) and Law (2007), as the most appropriate framework to guide me in addressing the issues raised above. ANT as a social theory has distinct tenets and conceptual resources that could be used to explore collaborative design as a networked process including both human and non-human actors as equal partners in the network. In this study ANT allowed me to explain the relational ties which led to the assemblage and stabilisation or destabilisation of the collaborative design actor networks that were assented to through interaction of engineering students and Web 2.0 technologies in collaborative design project.

In the next section I give a brief overview of ANT, paying particular attention to the distinctive tenets of the theory that are relevant. I present the concepts which are crucial for the analysis and understanding of the management of design using ANT as a framework. My aim is to tame the fluidity of the selected ANT concepts, with the intention of entering into its discourse and its use to construct an approach to understanding the role of Web 2.0 in the collaborative design process. ANT offers a unique opportunity for us to understand Web 2.0- facilitated collaborative design from a standpoint which does not distinguish *a priori* between designers and the technology tools used in the process. ANT considers both human and non-human as equally important actors working together to support the development of a satisfying design solution (Callon et al., 1986; Latour, 1999b).

ANT is the result of the criticism that has been leveled against traditional sociology, which disregards the role of the material and the natural in the constitution of sociology. It seeks to explain the notion of 'the social' through the networks of connections between human agents, technologies and objects (Couldry, 2008) rather than through an essentialised position of the social.

ANT first appeared in the field of STS through the works of researchers such as (Callon, 1986c) Latour (1986a, 1987b); Law (1986c, 1992). At this early stage ANT was concerned with how scientists achieved the support of others for their propositions about scientific facts, and how power and resources were acquired to perform their work (Van-House, 2003). As Law (1992, p. 386) concisely describes:

> This, then, is the core of the actor-network approach: a concern with how actors and organisations mobilise, juxtapose, and hold together the bits and pieces out of which they are composed; how they are sometimes able to prevent those bits and pieces from following their own inclinations and making off; and how they manage, as a result, to conceal for a time the process of translation itself and so turn a network from a heterogeneous set of bits and pieces each with its own inclinations, into something that passes as a punctualised actor.

By this, Law suggests that the main focus of ANT is to understand how actors, both human and non-human, come together in stable, heterogeneous networks of aligned interests. Thus ANT argues that both social and technical determinism are flawed. Its aim is to overcome the subject-object duality or the distinction between the social and the natural world. ANT deals with the social-technical divide by denying that purely technical or purely social relations are possible. Instead, ANT proposes a socio-technical account (Latour, 1996a) in which nothing is purely social and nothing is purely technical (Law, 1991). It argues that the social is not the glue that is holding society together, but that rather it is made up of essentially the non-social components that form the networks of relations that constitute it (Latour, 2005).

ANT stresses that the world is full of hybrid entities (Latour, 1991b) containing both human and non-human elements, and offers the notion of heterogeneity to describe processes such as collaborative design projects. When studying networked processes like collaborative design, ANT would entail that the researcher explores how these networks of actors and their relations emerge, are maintained, and compete with other networks of aligned interests, by tracing the transformation of these heterogeneous networks (Tatnall & Gilding, 1999).

However, there are many different opinions about the suitability of the term 'actor network theory' for this method of study. Callon (1986c) has used the phrase "sociology of translation", while Law (2009a) has argued that the term "material semiotics" is a more suitable way to describe this approach. Instead of calling ANT a theory, Fenwick and Edwards (2010) suggest that we think of it as a sensibility and a way of investigating how the socio-material enacts reality. Law (2009a), points out that ANT is not a theory because it does not provide us with explanations; instead it only describes and tell stories about how actor networks assemble together. In other words, as Fox (2005a, p. 102) stresses, ANT's goal is to "... to illuminate the processes, rather than explain end results ...". I should therefore hasten at this point to note that the different opinions on whether ANT is really a theory or not makes it an elusive term, thus making it difficult for me to say anything definitive about the term other than I have explained

in preceding discussion. Nevertheless, one thing that I am sure of is that ANT is more of a strategy for studying the world in action rather than a theory that could be used to test or development some hypothesis (Dicken, Kelly, Olds, & Yeung, 2001; Latour, 1994b, 2005; Murdoch, 1997). What makes it suitable for this study is that, as opposed to the positivist view of research methodology, ANT supports research practice that is messy and heterogeneous. In fact, Law (2004) argues that research by nature tends to be messy, since the world itself is inherently messy and lacks organisation.

2.1.3 Approaches to sociology

In order to understand ANT as a social theory we need to understand Latour's (2005) approach to sociology. Acording to Latour (2005), there are two approaches to sociology, namely, sociology of the social and sociology of associations or associology. What differentiates these two forms of sociology is that where as in the sociology of the social, the social or context is taken as a given, in the sociology of association, the social is produced through the associations created among the actors (Latour, 2005). Sociology of the social is the most popular view, and has been used by sociologists such as Durrheim to explain the social from the viewpoint of societal forces, the social overriding the biological, political, juridical, linguistic, etc., explanations, and therefore can be explained by social scientists.

Latour (2005) notes that the general trend within sociology has been to perceive the social as a given totality, which is "always already there," to provide a solid foundation for our understanding of any other phenomena. He notes that sociologists of the social treat the social as what explains phenomena, thus treating it as an entity that is already there exerting formative forces of its own on other entities. Since the sociology of the social perspective views phenomena from within a stable framework, its methodical approach depends on reductive methodologies that cannot account for process, formation, association, and contingency. According to Latour (2005), the traditional approach to sociology is concerned with the study of society and social forces and is contented with the undeniable existence of these social forces, and places its emphasis on humans as the only actors. Hence, in the sociology of the social the actors are embedded in a context that is readily available to explain the phenomenon being explored (Latour, 2005).

In contradiction of the sociology of the social's view of the social as a given, Latour (2005) argues it is in fact the social itself which requires to be explained and maintains that researchers must always ask how the social is constituted via which associations and involving what actors. This will allow scholars to pay their attention to all the possible agents and relations involved in a given assemblage. When explaining ANT Latour (2005) always starts by clarifying the meaning of the term social because he feels the term continues to be confused in sociology. In one of his explanations Latour (2005, p. 7), restricts the term social to mean only "a very peculiar movement of re-association and reassembling".

For Latour, therefore, the social no longer refers to the domain of things which can be isolated from the rest of other things and examined separately. Instead, the social now only refers to a way in which certain things relate to other things. The word 'social' is construed as all-embracing, including both human (social or subject) and non-human (material or object) actors. For Latour, therefore, there is no separate type of 'social' matter. Instead, the researcher's job is to trace the various links between actors which are connected with a given case. In the tracing, the researcher comes across many different networks of associated actors which contribute to the reproduction of the phenomenon. In order to understand the connections among the associated actors the researcher needs to be conversant with the differentiation which Latour makes between the roles played by the different actors in these connections: *mediators* and *intermediaries.* I will discuss these in detail later in the chapter, but briefly in Latour's vocabulary an intermediary is an actant which transports meaning or force without transformation, while mediators are actants which have the capacity to transform, translate, distort, and modify the meaning or any element they can carry (Latour, 2005).

According to Latour (2005), sociologists of association treat society as what must be explained and refuse to treat it as something that is already there. In his sociology of associations Latour (2005, p. 35) interprets sociology "not as the 'science of the social,' but as the tracing of associations". Latour's main argument is that when studying the social, the scale is not to be inserted by the researcher Veldman (2007), but should be the result of what actors do. This implies that as researchers we should remain open to the multiplicity of elements in a network and see all of them as actors, instead of viewing them as placeholders or nodes that exist only to uphold the structure of a predefined system that can only be deductively proved or disproved to be true. This is because Latour (2005) views the social not as a type of thing either visible

or to be postulated, but as a consequence of associations. The social only becomes visible by the traces it leaves (under trials), when a new association is being produced between elements which themselves are in no way social (Veldman, 2007).

Sociology of associations is concerned with tracing associations of actors and their heterogeneous relations. According to Latour (2005)' sociology of associations, social forces reside in the assemblages of thoroughly studied actants as opposed to unidentified social forces. Latour (2005)'s interest is in a sociology that studies the variety of associations between actors that constitute a phenomenon. He reminds sociologists to avoid skipping the step of tracing associations in order to form shorthand explanations of action. The job of an ANT researcher therefore is to continually study the assemblages that are formed and their constructions in action, rather than to arrive at fixed points where the creative forces have disappeared. To carry out an ANT a study the researcher must remain with the local, with the actors providing a 'thick description', of themselves: "when faced with an object, attend first to the associations out of which it's made and only later look at how it has renewed the repertoire of social ties" (Latour, 2005, p. 233). As a result, we can see a constant insistence on the study of action, of what becomes social actants, rather than a revelation of the imposing power relations or social forces behind an activity. As Latour (2005, p. 137) states: "there is only science of the particular".

By sociology of associations Latour refers to a sociology that traces social relations created among different actors. The tracing is made possible by the assistance of the actors involved in any given phenomenon, who will constitute the relevant actors from which a network is built. The danger of taking the social as a given in explaining the phenomenon being explored is that we deny actors the opportunity to account for their actions, as the associations among them unfold. In addition, the practice inhibits actors from making their own philosophies of what constitutes the social. However, the sociology of associations is mired in uncertainties, fluctuations and unknowns. Actors are observed in relation to dynamic associations and the (as)sociologist/researcher learns from those relations, rather than actors as situated in a pre-existing static social order to which they may become more aware and reflexive with the intervention of an omnipotologist. I will explore these uncertainties later in the chapter. Before this is done we need to elaborate on the distinctive tenets of ANT that are relevant to this study.

2.1.4 Theoretical implications of selected ANT vocabulary

Through sociology of associations ANT argues us to push aside the vocabulary of technical terms utilised by the sociology of the social as shorthand (Latour, 2005). Instead, ANT provides a whole range of resources that could be used by researchers to study actor networks as they arise from given situations. Every ANT researcher needs to have a clear understanding of these vocabularies in order for them to effectively employ ANT as a research framework. These unique ANT terms are not insular or isolated, but are dynamic, interrelated and interconnected. They incorporate, embrace, shape and clarify each other in a relational manner. Together these extraordinary ANT terms are used in the tracing and assemblage of networks in this study. They jointly unravel and demystify the tensions, uncertainties, contradictions and relationships in the actor network, exposing the 'networky' effect of the actor network.

2.1.4.1 The principle of generalised symmetry

The term association discreetly unveils ANT's alignment towards the principle of generalised symmetry. In simple terms, the principle of generalised symmetry argues that the categories of nature and society should both be described from the same vantage point (Latour, 2005). This position shows that the principle of general symmetry seeks to eliminate the dichotomy between objects and subjects. This is indeed a radical conception, because the position challenges that inanimate things such as Web 2.0 and the Internet in this case can also have agency, just as animate things have. The notion of actor therefore should be equally applicable to all actors within an actor network, including humans, technologies, animals, texts, etc. In fact, in some ANT studies for example, Hanseth, Aanestad, and Berg (2004) and Sarker and Sidorova (2006a) the word actant is often used instead of the word actor mainly because this term can be used to refer to both human and non-human entities involved in a network.

Through the principle of generalised symmetry ANT proposes a theoretical shift in emphasis, away from the centrality and primacy of the human subject (Latour, 1999a). Of particular importance is the fact that ANT grants agency to both human and non-human actors and is thereby considered to be non-dualistic. This is described in ANT vocabulary as the principle of symmetry. The principle of symmetry is reflected in the way ANT defines an actor. According to Latour (1997b, p. 2) an actor or actant in ANT is a semiotic being, that is, "something that acts, or to which activity is granted by others". Thus an actant can literally be anything, provided it is granted to be the source of an action.

ANT is distinguished by its ascription of agency to non-humans, thereby acknowledging the ability of any entity to make itself indispensable to its relationships with others in a network (Dwiartama & Rosin, 2014). This position is reflected by ANT's principle of generalised symmetry which holds a position in which humans are not given precedence over non-humans in their ability to take actions (Law, 1992). ANT proposes that inanimate things have agency to establish relations and translate interests. By taking this position ANT suggests that humans are not the only beings of agency. The term agent is defined as "anything that does modify a state of affairs by making a difference" (Latour, 2005, p. 71). Of significance, therefore is not the intentionality itself but how intentionality is shaped by its indorsement, encouragement or rendered possible by an extension of causal relations between humans and non-humans actors (Dwiartama & Rosin, 2014).

ANT provides puzzling explanations by focusing its attention on the relationships in which agents participate and how these are used to influence the shape of a network of related relationships. ANT posits that agency become visible only through the relation of actors to each other. This assertion suggests that material objects exert agency in a similar manner to humans (Dwiartama & Rosin, 2014). In addition to humans as actors, we should consider any non-humans, such as a machine, an animal and an object, as actors "if it performs, or might perform [agency]" (Callon & Law, 1995, p. 491). For example, in this case Web 2.0 technologies as actors in an actor network execute codes (action) to perform an action to meet the user group's (the network's) objective. In one of his studies, Latour (1992) discusses how a hydraulic door system is considered more reliable than a human operator or how a car seatbelt imposes morality on humans. Although it is often considered controversial, ANT protagonists insist that researchers must desist from distinguishing between human and non-human as prior categories in their analysis. ANT researchers are to treat actants within an actor network as a heterogeneous unit of analysis, with particular focus on network formation. This is because non-humans too can make a large contribution in bringing about or changing a phenomenon, just as a human actor can.

ANT's principle of general symmetry has profound implications on how we should view what actors are. In order for us to fully understand agency from an ANT perspective, we must first cross-examine more deeply our perceptions of the complexity of relationality by shifting our perspective from a system to a network. ANT's position, where non-human actants are viewed

as more active than is usually assumed, was a revelation for this study. As Latour (2005, p. 77) explains:

> ANT is not the empty claim that objects do things "instead" of human actors: it simply says that no science of the social can even begin if the question of who and what participates in the action is not first of all thoroughly explored, even though it might mean letting elements in which, for lack of a better term, we would call nonhumans. [...] The project of ANT is simply to extend the list and modify the shapes and figures of those assembled as participants and to design a way to make them act as a durable whole.

This position created an opportunity for me to study Web 2.0 technology as one of the actors entwined in relations with human actors in the assemblage of a design network. ANT, as Latour (1992, p. 227) points out, is concerned about the unnoticed "missing masses", that is the non-humans that are everywhere, strongly social and moral, but nevertheless overlooked by researchers. Pels, Hetherington, and Vandenberghe (2002, p. 1) have observed that in everyday life objects can no longer be taken for granted:

> Talking to intelligent machines ... being glued to mobile phones, roving around in cyberspace ... is to mingle our humanity with not-so-mute, active, performative objects in a way which we find equally fascinating as disconcerting.

These objects, especially Internet-based technologies, now belong to the human world in ways that are more than "instrumentality, efficiency or materiality" (Latour, 2002, p. 248). In today's information-based and networked society Internet technologies are no longer mere intermediaries, but are in many instances are on the verge of being our counterparts who can give orders on how we can do things (Jubie, 2013).

In this study I depend on the notion of symmetry in ANT to explore how Web 2.0 technologies (non-human) could actively participate as an actor in the shaping of the collaborative design process. ANT's orientation towards general symmetry allowed me to trace the trajectory of the collaborative design as it traverses the nodes of this study. It also allowed me to map the interface in respect of design artefact construction and the dynamics of collaboration across the nodes. This meant going beyond the simple acknowledgement of the potential of Web 2.0 in facilitating collaborative work, but considering the technology as one of the key participants that needs to be considered if one is to successfully explore the collaborative design process that takes place with the aid of these technologies (Irwin & Hramiak, 2010). This is because, as ANT suggests, these technologies have agency and cannot be taken for granted in a study that seeks to explain how collaborative design takes place. According to ANT agency refers to

the capacity of an entity to cause an effect and make a difference to a state of affairs (Callon, 1986c; Latour, 2005).

This gives agency to all entities in a networking, including non-humans. Latour (1999b, 2005) argues that by granting agency to both human and non-human actors we dissolve the uncertainty surrounding the nature of objects. This is because by according agency to nonhumans we are able to see the complete range of actors involved in the network being explored and the ties they form among themselves. Any entity that exists within a social system is rendered meaningful because of the network of relationships it shapes with others, rather than by its existence *per se*. To accommodate this attribute of meaning, ANT adopts the term actant to distinguish its perception of an actor as embedded within a network relationships from a more traditional conception which is usually defined by individuality and intentionality (Dwiartama & Rosin, 2014). An actant is thus defined as "an effect generated by a network of heterogeneous, interacting, materials" (Law, 1992, p. 383).

According to Singh-Pillay (2010), embracing the principle of general symmetry implies that one is better able to scrutinise the nature of the interaction that forms the building blocks of a network. ANT thus widens our lens as we consider the agency of non-humans and their relational effects on human intentionality. This has the potential to uncover the unsuspecting, behind-the-scenes actors involved in a practice. Therefore, ANT provides us with adequate analytical tools to identify all the actors and the relations they describe during their interaction in the network they constitute. As a result of the relational character agency, roles played by actors therefore cannot be fixed. Since the actors are involved in constant reforming networks, they are subject to different and changing roles (Dwiartama & Rosin, 2014). The rigidity or fluidity of the roles of actors within a network depends on the ways in which the actors continuously form networks among each other (Murdoch, 1998).

However, the only challenge which I see with regard to Dwiartama and Rosin (2014)'s proposal to trace the association between actors in ways which seems to ignore intentionality in favour of the effects of the actions taken by an actor in altering the course of events may compromise the quality our ANT account. There is a risky of us getting a shallow account of human action from such an analysis. It is not necessarily the case that intentions are left out in researching human actors, since intentions themselves can be considered as relevant actors in a network. In fact, from an ANT perspective any given human actor can be broken down into a whole range

of interrelated actors which contribute to the altering of events. In the next section I further elucidate the concept of actor network assemblages.

2.1.4.2 Actor network assemblages

This research adopts ANT as lens to explain the assemblage of a collaborative design network among engineering students in a working environment that is facilitated by Web 2.0 technology. According to Law (1999), ANT is focuses on the assemblages of actors into networks and the work that is performed within and through these networks of relations. As such, when employed to study a dynamic phenomenon like Web 2.0-facilitated collaborative design, ANT should guide the researcher to focus on the ways by which the designers, technologies, events and the design spaces form assemblages as they organise themselves into functional networks. The concept of assemblage is often used in ANT to direct researchers away from seeing actor networks as fixed structures, by conveying their image as dynamic entities under constant reconfiguration (Barry, 2001). Assemblages are tactical and contingent gatherings of actors into functional collectives for some purpose or set of purposes (Spinuzzi, 2008). The concept of networks as assemblages is relevant to this study because at an abstract level collaborative design may be viewed as an act of assembling entities and exchanging resources through a network of actors.

Harman (2007, p. 43), has observed that "An actant is nothing without networks; with networks, it is all". In ANT terms, a network is perceived as something within which things circulate; it involves connections between actors (Nespor, 1994) or fluid spaces (Law, 2007). The things that circulate within a network could be mediators or intermediaries (Latour, 2005). They are also seen as producing and constitutive of material spaces of social practice and as channels of communication (Nespor, 2002). Primarily, networks are perceived as contextualising and generating the social and natural world (Law, 2007).

Networks comprise of nodes that are linked together by the associations established among the actors. Each actor that is enrolled into the network occupies a certain position of the emerging actor network in order to strengthen the network. Furthermore, each actor network has at least one actor that exercises control on behalf of the controlling actor. This actor is responsible, among other things, for enrolling others into the emerging actor network, mainly through persuasion. However, since not all actors in the actor network start at the same wavelength in

terms of the purpose of a network, sometimes actors are enrolled through coercion. In fact, the actors who may be enrolled or persuaded to join the emerging network include: (1) actors who might not be sharing the same objectives with regards to the purpose of the network, but are enrolled once an agreement on the purposes proposed by the controlling actor is achieved; (2) actors who might be resistant to the roles they are supposed to play; and (3) actors who are disruptive and thus act against the interests of the network. More often than not the actors which are enrolled into the network have divergent views and, in some cases, opposing objectives.

ANT argues that networks can be traced, described (Latour, 2005), and seen as enacted (Mol, 2007). As such ANT offers an analytical lens to examine how certain situations unfold during the evolution of an actor network and how networks are stabilised through the process of translation. Therefore ANT researchers attend to how the assemblages of "thingly gatherings" (Thompson, 2015, p. 1). Latour co-constitute enactments of everyday practices with, in, around, and through human actors. It is through this socio-material turn that ANT offers an ontological questioning and framing that can engage with the fluidity of the digital.

The tracing of networks illuminates how socio-material elements participate in network practice and what gets performed through this participation (Mol, 2007). These elements (for example, design briefs, working drawings, technology) show how network relations get enacted into practice (Law, 2004; Mol, 2007). ANT demonstrates that networks are outcomes that emerge from complex sets of relations among heterogeneous elements (Latour, 2005). Entities emerge as their associations are consolidated. In observing movement via shifting associations, we see relations to which we were previously oblivious. Singh-Pillay (2010, pp. 25-26), notes that:

> Not only is the actor coming into being, but the practice itself is brought to the fore, is reinforced, changed or reproduced. The actor and the practice are interlinked.

Any actor that is enrolled in practice is performed anew within its particular context and through each enactment (Mol, 2007). A pertinent question arises: how do we choose the actors we have to follow?

The physical delimitation of my area of study comprise of three nodes, namely the design studio, the university's LAN and the Web 2.0 design space. These facilities were the core actors

around which the trails of associations that were traced were centerd. Within each node there are a myriad of other actors that drove and moved these nodes to constitute the collaborative design process. For example, at the design studio node students, design briefs and working drawing constitute the conspicuous actors that can easily be identified. I traversed these nodes picking up the trails and the translations that occurred during the constitution of the collaborative design process. I went in there with an open mind, just *following the actors* and collecting the traces they left behind since acceding to (Latour, 2005), the network and its actors are the starting- and end-point of the research. The actors within a node are identified by their association with the design situation and the other actors. The actors and the network they describe are mutually constitutive (Latour, 2005). Actors are viewed as being part of a network, and a we cannot talk of a network in the absence of actors, nor can an actor exist outside a network (Latour, 2005). According to Singh-Pillay (2010, p. 26), "both the actor and the network are important to allow for the unfolding of associations and to make the social apparent." By bringing the interconnectedness among actors to the fore, ANT is emphasising the importance a relational interplay among the actors in a collaborative network. This implies that the network metaphor can be employed to illustrate the work, practice, performance and relations of actors in a Web 2.0-facilitated collaborative design process. It does so by highlighting the collaborative design practices among the student designers via the network of relations they establish. For example, the design briefs are formulated at the design studio node, but implemented and enacted at the school node. The metaphor of a network clearly illuminates the type of relational continuity that feeds on reciprocal relations among the actors as a critical aspect of constitution of an effective collaborative design process. There is need for strong ties to be established among actors for an effective collaborative design network to be constituted. The affordances for a seamless interaction brought in by Web 2.0 technology and the techno savvy character portrayed by today's learners is a perfect mix for the development of an effective collaborative design process.

2.1.4.3 Performativity

In the previous section I established that ANT is interested in network assemblages. This implies that ANT is less concerned with the size of networks but rather with the dynamics of influence in and on networks (Fox, 2005b), which underpins a central concern of ANT with collaborative design as an emergent network. I also established that assemblages of heterogeneous materials or networks do not exist *a priori*; they have to be made (Law, 1999);

Porsander 2004). In other words, they have to be continuously performed through practices in specific time-spaces. So, practices make networks; it is through practices that associations between different elements are made. ANT, as described by Latour, can therefore be viewed as a performative science of how assemblages come into being and of what different kinds of actors do.

The concept of performativity suggests that collaborative design is not solely the representation of the design problem but rather it is the performance of those phenomena, a performance that is translated (Latour, 1987b). Viewing design as performativity renders all its characteristic distinctions as performed (Law, 2004; Law & Urry, 2004). The design network is therefore not natural and static but dynamic and enacted through practices (Christian, 2009). As a network in action, the design process creates its own dynamics. This implies that actors in the network change form, shape and position, and cannot rest assured of what or where they are to whom. The actors can only be identified as being something in particular from the agency they derive from the shape and history of the network they enact at a given time. The design process can therefore be viewed the expression of some relations, which simultaneously ignores and pushes others to the back (Law, 2000). Those relations that are presented are those that support focal actors' views and the agreed upon goals of the design project.

2.1.4.4 Sociology of translation

One of the central concepts in ANT that critical to this study is the notion of translation. Translation is defined as the processes that generates ordering effects, that is, the process that forms the actor network (Law, 1992). It constitutes "the methods by which an actor enrols others" (Callon et al., 1986, p. xvii) or "a process of mediation, of the interpretation of objectives expressed in the 'languages' of different intermediaries engaged in an innovative project/process, intermediaries whose viewpoints and interests are not, initially, necessarily the same" (Buzelin, 2007, p. 137). Translation is unpacked into four moments, namely problematisation, interessement, enrolment and mobilisation.

During the problematisation, a focal actor frames the problem and defines the identities and interests of other actors, which are coherent with its own interests (Sarker & Sidorova, 2006b; Tatnall & Burgess, 2002). The major aim of problematisation is to "induce consent and provoke resistance in various groups" (Callon, 1980, p. 215) by defining, equating, simplifying and

displacing interests and goals into a set of relations. The focal actors deploy strategies that work upon, transform, link, merge and displace the interests of others in such a way that the other entities consent to the focal actors' imposition of the problematisation. Such a translation of interests induces consent by suggesting relations between problems/groups, as well as by accommodating and constraining how other actors could orient themselves towards the uncertainty imposed upon it (Shiga, 2007). The focal actor renders itself indispensable by defining a process under its control that must occur for all actors to achieve their interests. This is called an obligatory passage point (OPP) (Callon, 1986c). The OPP is naturally in line with the focal actor's preferred way of achieving its interests. However, other actors might have to overcome some obstacles in order for them to pass through the OPP (Callon, 1986c; Tilson & Lyytinen, 2005). The definition of the interests of others and of the OPP by the focal actor are part of the focal actor's strategy for aligning the interests of others with its own. (Tilson & Lyytinen, 2005). The establishment of the OPP practice means that the focal actor has imposed its views on others. This suggests that the problems other actors may have could only be resolved by passaging through the OPP (Law, 1986b). Other actors pass through the OPP by modifying their current interests to align them to those of the controlling actor. The focal actor becomes successful by imposing its propositions as OPP.

The second moment of translation is the interessement. This involves the actions by which the controlling actor of the network interests others to agree with their proposal (Callon, 1986c). Interessement involves the controlling actors of the emerging network inciting actors into fixed places (Tatnall & Burgess, 2002), and weaken the influence of other actors that may disestablish the developing network (Callon, 1986c; Linde, Linderoth, & Räisänen, 2003). As Callon (1986c, pp. 207-209), points out:

> Interessement is the group of actions by which an entity [a controlling actor] attempts to impose and stabilise the identity of the other actors it defines through its problematisation … to interest other actors is to build devices that can be placed between them and all other entities who want to define their identities otherwise.

The focal actor executes these strategies to convince other actors to accept its definition of their interests (Tilson & Lyytinen, 2005). It should be noted that those being targeted for interessement might also be simultaneously targeted in the problematisation stage of other networks, and might therefore define their identities and priorities differently from the interests of the emerging network. Therefore for the controlling actor to achieve a successful interessement, the actor needs to employ tactics that can isolate those being enrolled by

impeding any other possible alliance that may challenge the legitimacy of the established OPP (Sarker & Sidorova, 2006a). For interessement to be deemed successful, it needs to achieve enrolment.

Interessement alone does not necessarily lead to successful alliances and eventually translations. Callon (1986b), suggests that interessement needs to be reinforced by enrolment. He points out that enrolment consists of "negotiations, trials of strength and tricks that accompany the interessements and enable them to succeed" (Callon, 1986b, p. 125). For enrolment and the desired alliances to succeed, the roles of the enrolled actors must be defined in line with the scheme proposed in the OPP (Law, 1986c; Linde et al., 2003). The negotiation should not be limited to only those initially targeted actors but should be expanded to include those which can potentially threaten the emerging network's stability. However, negotiations are not always necessary, because some actors can be enrolled into a network without any resistance. For example, in many design projects in universities all the students will be by requirement and are supposed share the problematisation statement. Therefore, for the most part the negotiation is carried out between a few tough actors (Callon, 1986b), illustrates the different possible ways in which the actors are enrolled, which include physical violence, seduction, transaction, and consent without discussion. Enrolment also includes the definition of roles of each actor in the newly created actor network (Tilson & Lyytinen, 2005).

The last moment of translation is mobilisation of allies. During mobilisation the controlling actor has to "accumulate enough allies in one place to modify the belief and behaviour of all others" (Latour, 1986b, p. 29). To achieve this, the controlling actor "borrows the force of the passive agents that it has enrolled by turning itself into their spokesman and talking on their behalf" (Law, 1986a, p. 16). An even larger network of absent entities that support the proposed solution is created, and thus gains wider acceptance (Tatnall & Burgess, 2002, p. 185). Hence, at this stage the controlling actor might have developed a relationship with only those who represent the masses, assuming that those represented will follow their representatives.

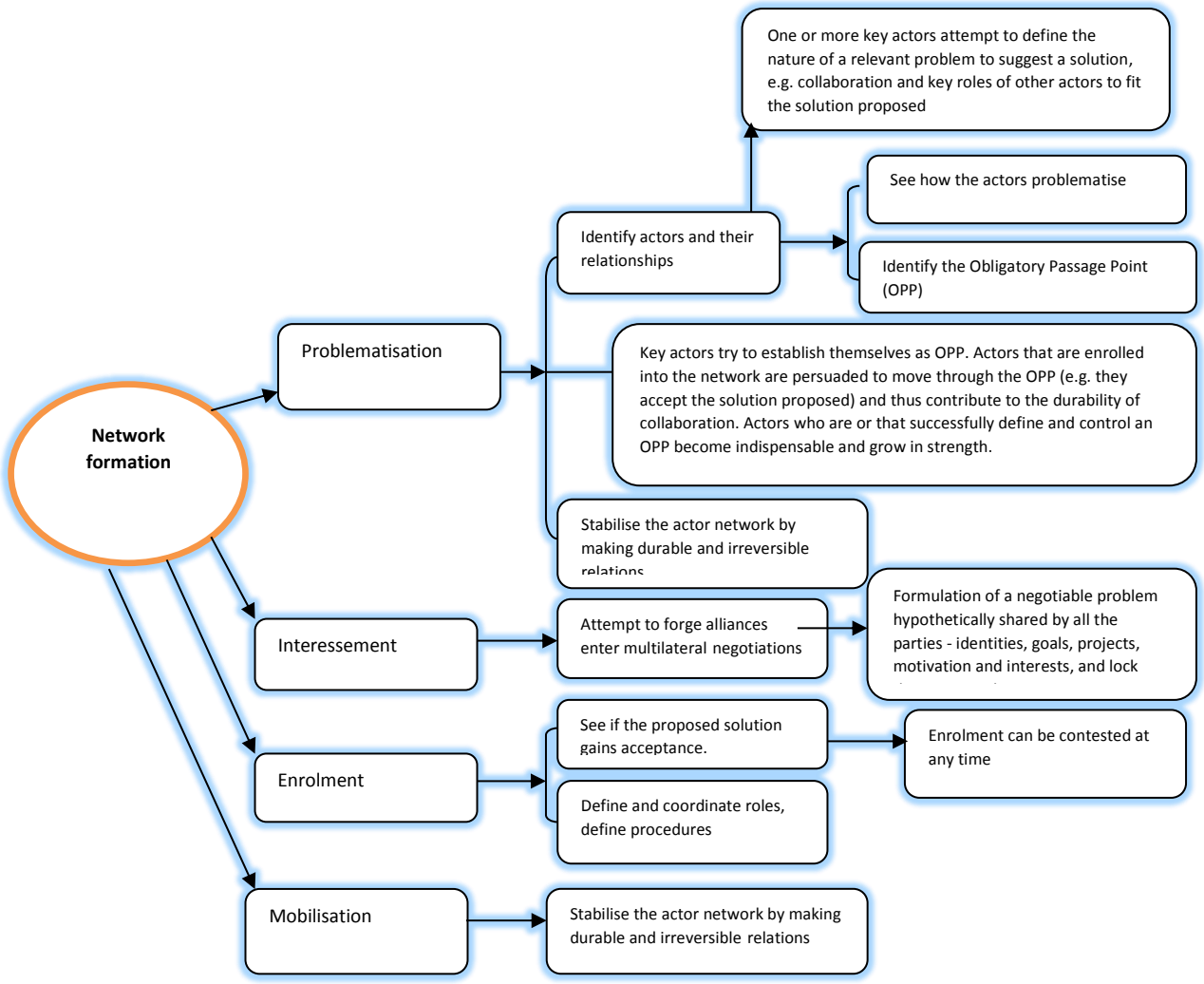

Figure 3: Summary of the collaborative design translation process

Figure 3 provides an overview of ANT and illustrates what I conceptualise as how the main concepts operate and intertwine with one another in the collaborative design process. Networks are created through the alignment of interests among the enrolled actants. As new actants enrol into a network, they accept their allies' interests through a process of translation. The translation process materialises their agreement with their participation and efforts to stabilise the network. The translation processes in an attempt by the network to become what has been often described as the black-box, which is irreversible and implying that the actors cannot explore alternative opportunities at this point. Nevertheless, translation processes are not always successful. When those who drive the process of translation fail to get other actors to comply with them, a process of dissidence, rather than a successful translation, takes place. Thus, those aimed to be mobilised question or refuse the roles imposed upon them by the controlling actor (Callon, 1986b).

As the four phases above suggest, translation is a multifaceted interaction process. It allows actors to align their interests by formulation of agreed definitions and meanings in order to work together and co-operate in the pursuit of individual and collective objectives. In instances where interest are aligned through settlement of controversies, be it temporarily, the network can become an OPP and possibly irreversible. This is, however, not easy to achieve in collaborative design because it is not always possible to resolve all the controversies on alternative solutions to the design problem. The collaborative design network is rather dynamic and ever evolving. In the face of a new problematisation the network may change, be torn apart, fail to consolidate, or self-adapt. There is also a possibility that those represented might not follow the spokesmen, but instead might challenge or refuse. When this situation happens a new actor who can be heard as a spokesman emerges, and obviously with their actions diverts those actors enrolled in the past through the failed OPP. As Callon (1986b, p. 125) argues: "Translation continues but the equilibrium has been modified … reality begins to fluctuate" and a new translation process starts to take place, but this process of ordering is never completed.

If we take collaborative design as a networked activity, ANT's concept of translation becomes a key resource to our understanding of the assemblage of the design network. The design process can be viewed as a translation through which the design brief or problem is transformed into a design artifact. The translation process involves a myriad transformations that take place among the actors as they work to provide a satisfying design solution. It is a dynamic process by which actors constantly work closely under the leadership of an indispensable actor, who is the spokesperson. The spokesperson of the network, is expected to work tirelessly to keep the network going. As Fenwick and Edwards (2010), has noted actors work to both generate as well as order and to stabilise their network. It is important for me to mention that actor networks that develop strong and stable ties among their actors can become taken for granted and used as packages or resources in the continued construction of actor networks (Latour, 1987b). In ANT terms such networks become 'black boxes', and can include agents, devices, texts, relatively standardised sets of organisational relations, social technologies, boundary protocols or organisational forms (Law, 1992). Black boxes exhibit the property of irreversibility, which is "the extent to which it is subsequently impossible to go back to a point where that translation was only one amongst others; and the extent to which it shapes and determines subsequent translations" (Callon, 1991, p. 150). Irreversibility not only makes it difficult to undo previous translations, but also constrains future possibilities (Tilson & Lyytinen, 2005). In design this

tends to inhibit future development in design solutions or procedures. However, ANT opens such black boxes and reassembles the practice to allow new networks to come into existence from such networks.

As an analytical framework, translation has a specific, technical meaning: "a relation that does not transport causality but induces two mediators into coexisting" (Latour, 2007b, p. 108). It is a continuous process that describes the movement of different forms of knowledge, cultural practices, technology, and artefacts (Czarniawska & Hernes, 2005). For this study, the conceptual ideas of the sociology of translation and its related concepts serve as analytical devices to explore:

1) how the collaborative design project was carried out using Web 2.0 technologies, and
2) how the participants, both human and non-human, in the collaborative design project were enrolled into the network to support the collaborative design process.

In other words, I used the concept of translation as an analytical tool to identify and explain who the actors were, what they said or did, or who they said they wanted to become (Latour, 2005). It is only when this premise is employed in this way that Callon's moments of translation can be appreciated as an analytical tool to illuminate network dynamics involved in a Web 2.0 facilitated collaborative design process. Since translation is not a linear, one-way process, it is important to highlight that the perspective taken in this study sees the moments of translation as having the potential to overlap, sometimes in a disorderly and iterative fashion.

2.1.4.5 Inscription and inscription devices

In relation to the translation process it is relevant to look at inscription devices. Latour and Woolgar (1986), define inscription devices as compositions of devices, that translate an entity into a figure or diagram (Jensen, Lauritsen, & Olesen, 2007, p. 68). Inscription devices are technical artefacts that record, and thus translate, nature, particularly in a visual representation (Latour, 1987b). Designers use a multitude of instruments that make nature 'accessible' through the inscription of measurements as graphs, illustrations or drawings. Designers may also inscribe in the design artefacts the patterns of use, which in this case may be relatively flexible in the nature of their use, for example. These devices often punctualise the inscription device's actor network and natural phenomenon being inscribed in the resulting graphic representation. Through the translation process actors try to stabilise a network and establish

social order though engagement in continuous negotiation to align particular interests (interpretation, representation, or self-interests) to mobilise support. In a design network inscription then seeks to translate specific actor interests within technical objects, for example text, software, user requirements or regulations, which typically impact on actors' roles.

In the process of inscription the properties of a setting are assembled, bearing the mark of the actors aligned in the network, which produces that setting (Tilson & Lyytinen, 2005). Inscriptions are typically provided with more concrete content to record actors' interests within a material, which varies in flexibility, for example, design working drawings, regulations and user requirements. They are given a concrete content because they represent interests inscribed into a material. As Law (1992, p. 387) points out:

> Thus a good ordering strategy is to embody a set of relations in durable materials. Consequently, a relatively stable network is one embodied in and performed by a range of durable materials.

However, some inscriptions inscribe weak/flexible programmes of action, while others inscribe strong/inflexible programmes (Tilson & Lyytinen, 2005). For example, design tools such as the hammer may inscribe weaker programmes of action, whereas working drawings my inscribe procedures that design has to follow to produce the desired artefact. According Monteiro (No Date) "the strength of inscriptions, whether they must be followed or can be avoided, depends on the irreversibility of the actor network they are inscribed into".

In design it is never possible to know beforehand which inscriptions may lead us to a successful design project. It is only through the tracing and assemblage of the sequence of attempted inscriptions of the actor network that we learn more about exactly how and which inscriptions were needed to achieve a given aim. For example, in a design project, in considering what it takes to establish a specific work routine one may try to inscribe the routine into required skills through training. If this inscription does not work, one may inscribe the routine into a textual description in the form of manuals. Therefore it is evident that through the process of translation the design process may be inscribed into components of different materials, which could be linked together into a socio-technical network. The strength of the design network could be enhanced by superimposing these inscriptions to accumulate strength. In this way the network becomes increasingly irreversibly entwined, bound together, integrated, and made up of established, inseparable, interdependent actors (Callon, 1986a, 1991). At this point actors may be transformed, destroyed, or expelled from the network, but neither they nor the network can

be unraveled or reversed along its trajectory of development. For example, an actor may leave a network and get replaced without changing the course of the design project. It should be noted that non-human actors can play a powerful role in establishing irreversibility – which might not always to the benefit of the network, as they can produce inflexibility within it.

Translation and inscription play a fundamental role in the analysis of actor networks. For example, according to Jensen et al. (2007, pp. 68-69) inscription devices:

> "…make it possible for researchers to describe processes without being disturbed by their complexity, and can therefore be used as a tool not to make the usual interpretations of scientific work."

Another important consideration for the use of inscription devices is that they are often black boxed, what they are meant to transmit, implying that they are often made to act as intermediaries (Latour, 1987a).

2.1.5 ANT's perception of controversy

Collaborative design is characterised by uncertainties and ambiguities, which result in controversies concerning the appropriate strategies to respond to the multiple challenges and transformations which humanity is facing. In fact the design process can be viewed as a series of tasks and decisions for reducing uncertainty. In ANT terms uncertainty refers to the state of not knowing "who or what" makes us act (Latour, 2005). This means that since there are a number of unknown agents that could be acting when we act, our actions as actors are therefore not necessarily a result of consciousness (Latour, 2005). Grebici, Goh, and McMahon (2008, p. 1), note that "In a collaborative design project uncertainty is often considered as a lack of knowledge that may introduce risks to the outcome and execution of a process". These may emanate, for example, from conflicting design requirements which may introduce ambiguity in the definition of the design problem and its solution. Guided by the sources of uncertainties, illustrated by (Latour, 2005), I illuminate the uncertainties that are relevant to the collaborative design actor network.

As we will see in Part B of the literature review, collaborative design involves resolution of various controversies and uncertainties with regard to the production of the design artefact that can solve an identified problem. Grebici et al. (2008, p. 1), note that; "In a collaborative design project uncertainty is often considered as a lack of knowledge that may introduce risks to the

outcome and execution of a process …" The same authors further suggest that as a starting point, sociology must address all the possible controversies involved in living together, without making restrictions on the controversies to be explored in advance. Then sociology must show us how those controversies are or may be settled – or in Latour's language, stabilised – and how those settlements are or may be maintained. Sociology's final task would be to define the procedures for reassembling the collective of interest and useful to those who have been the objects of study (Markman & Wood, 2009).

The uncertainty associated with the method and information will have impact on how design is carried out, and therefore these need to be identified so that they can be attended to during the design process. Latour (2005), identifies five sources of uncertainty which need to be resolved before the network tracing and assembling process can start begin. These are (1) the nature of group formation; (2) the nature of action; (3) the nature of objects; (4) the nature of facts; and (5) the type of study. Latour (2005), points out that failure to first consider the resolution of these uncertainties results in us rushing to tracing networks, "by turning to the social in order to explain the phenomenon under exploration" (Singh-Pillay, 2010, p. 29). It for this reason that, Latour (1999b, 2005), give ANT's primary goal as to describe the nature of societies by tracing these sources of uncertainties.

Therefore, in every ANT study the resolution of these uncertainties is a precursor to the tracing and assemblage of networks. In this study, therefore, the five uncertainties identified by Latour had to be resolved in one way or another because they are linked to one another. Since these uncertainties are intertwined, tracing of the collaborative network required me to constantly resolve the uncertainties by relating one concept to another. This indicates that the tracing process is not conducted in a linear fashion, but rather is an ongoing process comprising uncertain, shifting and heterogeneous ties (Latour, 2005).

The first controversy pointed out by Latour (2005), is that with regard to group formation. This controversy begins with a question about which group is responsible for a particular role; for example, in the case of the collaborative design group, the question can be who is responsible for selection of the design problem which students can work on. To answer this question it was then necessary to trace the relationships among all the actors involved in the group formation. Group formation involves enrolments, tensions, uncertainties and translations, which implies that actors within a group/s are constantly relating to one another in an ongoing manner, leading

to ever-shifting ties or associations among the actors (Latour, 2005). These ties are said to be fragile, uncertain and controversial (Latour, 2005; Singh-Pillay, 2010).

The shifting ties point us to the fact that there are no fixed relations, and therefore the researcher cannot confine actors to them (Latour, 2005). The research's business is to just follow the trajectory of an actor in the network. Following the trajectory in a collaborative design process would entail focusing on the tensions, uncertainties and translations among the actors when they form and dismantle associations, which provide the researcher with the resources to render the social connection traceable (Latour, 2005). By the same token of reasoning, these shifting ties or frames of reference allow the social to become visible and also lead to the formation of contradictory cartographies (Singh-Pillay, 2010). The ties would allow me as the researcher to unmask aspects of the social impact on the actors' actions, given that action is not transparent but has to be traced (Latour, 2005, p. 43).

Latour (2005), argues that the delineation of a group is done through defining its boundary, and further argues that it is the task of the actors to delineate their boundaries. To do this the group requires a spokesperson or a focal person who will represent the group in defining what the group should be and has been. When associations in a group are formed or dismantled their spokesperson tries to define them and the group's boundary gets marked, delineated and rendered fixed and durable (Latour, 2005). This means that the boundaries created by the spokesperson hold up against the contradictory pressure of all competing associations that threaten to dissolve the group boundary. This shows that groups are not silent, but are the product of an uproar made by contradictory voices (Latour, 2005). Demarcation of boundaries results in a stabilisation period in respect of the associations, translations and group formations and the nature of action and object. Methodologically therefore, it is the uncertainties among the actors that dictate which sociological theory the researcher ought to use. Therefore it is not proper to define in advance what sort of social aggregates provide the context for mapping these associations. In other words, the actors do the sociology for the enquirer, and the enquirer learns from the actors what constitutes their sets of associations (Singh-Pillay, 2010).

The second source of uncertainty encourages us to emphasise who is acting when action occurs. Here Latour draws attention to a problem in the social sciences where awareness that we are never alone in carrying out a course of action becomes an assumption that 'social force' has taken over (Latour, 2005, p. 53). Thus, we must move beyond a concern with 'social forces' to

a concern with the uncertainties and controversies around who and what is acting when the group acts. This in turn brings to light the realisation that what makes us act has the potential to be assembled in new ways. ANT encourages us to appreciate the necessity of "remaining puzzled" about how the agencies that make us act actually make us act, and this must be done by making observable traces "more or less explicit" (Latour, 2005, p. 53).

The third source of uncertainty mentioned by Latour engages with the idea that the range of actors at work in any consideration of 'the social' has to be increased. In ANT there is a concern with the implements that "modify a state of affairs by making a difference to an actor" (Latour, 2005, p. 79). Rather than seeing objects as being in the background of human action, they are positioned not as only full-blown actors, but also as what explains the contrasted landscape we start with. The argument here is to dissolve the categorisation of 'social' and 'material' to explore the agency of all sorts of actors including, for example, designs diagrams, artefacts, tools, computers and the Internet tools that allow interactions among actors in the network. Thus researchers need an extended range of tools that allows objects to enter into their accounts of what happened. However, researchers have to note that Latour (2005, p. 79) has observed that objects are good at being silent and "specific tricks" need to be invented to "make them talk".

In the study of Web 2.0-facilitated collaborative design a number of solutions are offered, which include studying inscriptions which appear in design meetings, design portfolios and the Web 2.0 postings. This also includes exploring unexpected incidents such times of breakdown of Internet connectivity, since such situations render visible what objects do as the destabilised actors they are to restore stability in the design network. Furthermore, the voices of receding non-human actors can be rendered visible through the use of archives. It is important that researchers explore all these avenues, because the network can only be fully described if all the relations among the multiplicity of its actors are uncovered.

The fourth source of uncertainty leads to a suggestion that agencies are engaged with 'matters of concern' rather than 'matters of fact'. Here Latour draws on the way that scientific knowledge, including social scientific knowledge, is constructed in scientific practice. For example, ANT suggests that if we consider the controversies of science studies, we can gain an understanding that matters of 'fact' cannot describe a 'unified reality'. This is not to say that facts do not exist, but rather it is an invitation to researchers to challenge any premature notions

of indisputability that might be presented a matter of fact (Latour, 2005, p. 116). Furthermore, the fifth uncertainty suggests that our explorations of initiatives such as collaborative design must recognise that our reports in themselves are mediators: they transform the meaning of the elements they carry (Latour, 2005, p. 40).

When these ideas are applied in the study of collaborative design, they imply that the inquirer should examine how during a collaborative design process the controversies are settled (stabilised) or not. The inquirer should identify the actors involved and how the controversies (design issues) are articulated, so that they can be addressed effectively. For any collaborative design process to achieve its goal, the actors involved need to find ways of addressing the controversies they encounter so that they expend their energy on solving the design problem (Bryson et al., 2009). The presumption is that if the controversies are not stabilised appropriately things will fall apart where the design project endeavour is concerned. There has to be an alignment of interests (understandings, agreements and commitments) on controversial issues pertaining to the design problem if the design process is to achieve its goals. For design researchers an ANT lens can be instrumental in illuminating how and to what extent design controversies could be stabilised (Bryson et al., 2009).

2.1.6 Summary

In Part A of Chapter 2 I explicated the challenge in searching for a theoretical framework that allows for the tracing of a trajectory of the collaborative design actor network involving heterogeneous actants, including both human and non-human actors. I identified ANT as the most appropriate theory that could draw from the strength of qualitative research to provide a powerful but somewhat different framework for understanding collaborative design (Tatnall & Gilding, 1999). The tracing and assemblage of the network is made possible by ANT's distinctive tenets together with its vocabulary, which I have explored. I have also revealed ANT's commitment to methodological approaches that do not privilege the human as a symbolic or ideological representation of some social force that can be posited generally. Instead, ANT approaches relations from the premise that there agency is is found behind particular aggregates of association.

ANT questions any understanding of the social that propagates a centralised understanding of relations that can be framed within a single direction or explanation. Instead ANT seeks to

uncover new associations, relations, and connections, which are always unfolding through the actions of actors and groups themselves. ANT does not bank on a hidden or extraneous explanation of a set of associations that presupposes a stable relation. ANT is mostly concerned with tracing new connections, concepts, institutions, technologies and procedures, among other things, in order to reassemble and reconnect the social.

In the last section of this part of the literature review I also highlighted that there are some tensions, uncertainties, controversies and translations that actors encounter in the associations that they are involved during their actions in the networks they traverse. In the case of collaborative design networks, this shifts our attention from what is believed to be already assembled to the process of assembling itself, since it during this process that the uncertainties are resolved. Our interest in collaborative design is in what happens in a networked process that is initiated in response to the "wicked problems" (Rittel & Webber, 1973) of the design situation.

In Part B of this chapter (Chapter 2), I review literature on how design has been conceptualised in theory in order to illuminate the gape that exist between design theory and the practice of design in today's networked society.

PART B: TRACING THE CONCEPTUALIZATION OF DESIGN

2.2 Introduction

This part of the literature review seeks to illuminate the need for a paradigm shift in the way we conceive the design process and how it is practised, in view of the increasing development in digital communication tools such as Web 2.0 technologies. I accomplish this by tracing how the concept of design has evolved, from it being viewed as an individual activity to it being viewed as a collaborative process. I employ the ANT lens to assemble from the literature an argument for the need to view design as a networked process comprising heterogeneous human and non-human actants.

2.2.1 Mapping the tracing of the conceptualisation of design

To expand our knowledge of collaborative design as a networked process, we need to trace how it has been conceived by different scholars over the years. This section is dedicated to tracing the past and present conceptionalisation and further projecting the future perspectives of design as an emergent networked process. I accomplish this by following the traces of the definition left by the key actors in design literature, in order to assemble an argument that pushes for an understanding of collaborative design as a networked process. This in ANT terms is a translation of design literature inscriptions, including journal papers, seminal papers and books that are shaping the meaning of design from the purely technical rationality (Simon, 1969), to the social perspective (Bucciarelli, 1994), to my proposed view of collaborative design as an emergent networked process.

During the relatively short history of design research there has been constant change in the way design has been viewed, from being an individual, problem-solving activity to being discussed as a social activity involving many people. At the early stages of design history, design was conceived from a psychological perspective as a form of behavioural activity involving, for example, cognitive processes such as analysis, synthesis and evaluation (Archer, 1963; Asimow, 1962). On this basis the design process was represented by logical design models, which held on tightly to the dominant forms of behavioural science activities. Consequently the dominant view of design in the early 1960s was the view of design as an individual mental activity. Hence, design was presented as a procedural or phased process which could be applied

generically to a wide range of design activities, from the technological to the creative fields (Jones, 1970; Stumpf & McDonnell, 2002).

As a result design has been viewed from four major paradigms, namely: problem solving (Simon, 1969), hypothesis testing (Broadbent, 1984), experimental learning (Schön, 1991) and social process (Bucciarelli, 1984). In the following section I discuss these and other design perspectives so that I can demonstrate their deficiencies in describing collaborative design in the face of the increase in information technology such as Web 2.0 technology. At the end I will propose a new view of collaborative design as a networked process that involves the translations of heterogeneous actors.

2.2.1.1 Design as problem solving

The problem-solving approach to design is influenced by Simon's efforts to have design considered as a science like physics and other natural sciences, and have it constitute part of the engineering curriculum at university level (Simon, 1996). Prior to this design was only a sub-topic of engineering studies and was not considered prestigious enough to be incorporated into the engineering degree curriculum of universities. Using examples from cognitive psychology, computer science, public administration, economics, management, philosophy of science, sociology, and political science, (Simon, 1969) demonstrated how design can be implemented through problem-solving processes.

The view put forward by Simon (1996) describes design as being essentially a problem- solving process where the designer, searches the space of possible solutions for a satisfactory solution to the given design problem. Essentially, this perspective regards designers as problem solvers, whose work on a design project starts with understanding the design problem and ends up with a solution to the problem, which can be either a new product, a service or a process. Simon's theory stresses the rationality of the design process and reduces the complex nature of designing to a goal-oriented activity. It assumes that the designer deals with the ill-structured design problems by decomposing them into smaller, easily definable sub-problems. Simon's problem-solving approach equates designing with the scientific method of inquiry in which the scope of the steps taken towards a solution can be determined prior to the design task. The process is considered to involve distinguishable processes that occur over time.

Describing the design process as a rational system is only suitable in cases where the design problems are well structured and allow designers to have complete strategies to be followed in solving problems. However, in practice engineering design problems are complex. They are often presented as complicated and ill-defined, to the extent that design actions cannot be accomplished through carrying out a predetermined plan or a programme of action given at the beginning of designing. In real-life design problems all the relevant information required for the process cannot be predicted and established in advance of the design activity. The directions that are taken during the examination of the design terrain are influenced by what is encountered along the way, and the insights that the designers gain as they reflect upon their actions (Cross, 1999). Thus the constitution of the design process is dependent upon the actions that designers encounter during the course of providing a solution to the design problem.

In disputing the problem-solving approach, Agre (1997) points out that the model does not account for improvisation or the "the continual dependence of action upon its circumstances". The model does not allow for differing agendas that stakeholders within the design process may have (Ehn, 1988). This is particularly pertinent for interdisciplinary and group design work.

As Rittel and Webber (1972) note, design problems are ill-structured and "wicked", and hence are too complex to be solved by prescribed problem-solving methods. The complexity of a design problem does not just emanate from the features of a problem, but also from how the designer interprets and interacts with it. Therefore design is not only about the type of problem – it also involves the way of looking at a problem (Thomas & Carroll, 1979). In real- life product design processes engineers encounter complex problems involving a lot of uncertainty and controversy, with unexpected design sub-problems that they encounter along the way. The design process involves the unexpected expansion of the initial scope within which the design problem is initially framed. Uncertainty and controversy arise, because for the designers to determine effective solutions to problems they must define the goals, criteria, and constraints, while responding to this dynamic nature of the problem's boundaries.

The main problem for designers is to conceive and plan for that which is not yet in existence, and this takes place in the context of the indeterminacy of wicked or ill-structured problems before the final result is known. In fact, design problems are indeterminate and wicked because design itself as a discipline does not have special subject matter of its own, apart from what a

designer conceives it to be (Buchanan, 1992). Both the problem and the solutions are fluid and can therefore not be predetermined. Since both the problem and solution spaces co-evolve, the designers' attention shifts back and forth from defining the problem to solving the problem. This makes the design solution a process rather than a one-off decision.

I am, however, not disputing the fact that designing sometimes includes stretches of conventional ill-structured problem solving (Dorst & Royakkers, 2006). Nonetheless, any model of the design process that tries to reduce design to ill-structured problem solving is bound to miss important aspects of the design activity (Hatchuel, 2002).

I have argued in this section that design cannot be considered a purely scientific process or a mere problem-solving activity. Such a model therefore cannot help us to understand the complex process of designing in the face of increased technology use in the design process. Web 2.0 technology increases the complexity of the design process such that the problem-solving models cannot capture the dynamics of the process in practice.

2.2.1.2 Design as a reflective practice

An attempt to improve on the rational problem-solving approach to design is offered by Schön (1984), who proposes design to be viewed as a reflective practice where the designer is constantly in conversation with the design situation. Schön (1983) criticises the problem-solving model as a technical rationality which does not take into consideration the engagement of the design with the situation of the design. He argues that design theorists who work within this view restrict themselves to matters of generalities about the processes of designing. Schön notes that the problem-solving approach pays little attention to the structure of the designing tasks, and the need to link the design process to the design task in the design situation is downplayed.

He argues that one way in which the problem-solving model over-simplifies the design process is in the assumption that there is a definable design problem to start with. This is not always the case; design problems have been characterised as indeterminate, wicked and ill-structured (Rittel & Webber, 1972). In this regard Schön (1983) notes that the proposal by Simon to fill the gap between the natural sciences and design practice with a science of design is still inadequate, because the proposed science can only be applied to well-structured problems already extracted from situations of practice.

As such, Schön (Schön, 1983, p. 50) proposes an alternative model of designing, based on the idea that "a kind of knowing is inherent in intelligent action". Schön's argument is that the basic elements of any given activity are actions and the central issue in designing is the ability to make intelligent decisions about these actions. Schön (1983) describes a situation where designers do not use espoused theories when they design; instead they work with context-specific "theories in use" in which they learn by doing. Schön argues that in practice designers react to the new state of their own making, and the design process can therefore be argued to be constituted by these interactions.

In his concept of reflective conversation with the situation, Schön (1983) points out that designers name the relevant factors and frame a problem in a certain way as they make the necessary moves towards a solution and evaluate these moves. The naming activity involves designers explicitly identifying relevant objects in the designing task. In the framing activity, the designers are involved in distinguishing the context in which other design activities take place. The moving activity is a complex activity which not only involves the designers in trying to solve the problem, but in exploring the suitability of the frame to be used in the process (Schön, 1983). Therefore these design activities are not simple tasks that can be accomplished in the predetermined linear fashion of problem-solving technical rationality. They involve a lot of uncertainties in the face of which designers have to take ad hoc decisions in order to proceed.

In Schön's view of designing the central idea is the reflective and conversational nature of the process. Instead of starting out with a clear problem definition or goal for the design, the designer constructs the design gradually by experimenting with design moves and thereby gaining "a new understanding of the phenomenon and a change in the situation" (Schön, 1992, p. 68). In designing a reflective practice, Schön distinguished between reflection in and reflection on action. Reflection in action refers to the student who, whilst carrying out their design work, comes across something unexpected. Through reflection in action designers learn from their experiences and subsequently modify their work. He refers to this as acts of "seeing-moving-seeing" (Schön, 1992, p. 5), in which the designer firstly evaluates their current work, then moves their work by modifying their design, which leads to a new evaluation of the design (Gero & Kannengiesser, 2003). Reflection on action, on the other hand, is retrospective and occurs when a student looks at the actions and work they have already done in order to learn from past experience.

Describing designing as a process of reflection in action works particularly well in the conceptual stages of the designing process, where the designer has no complete strategies to follow in proposing and trying out problem/solution structures (Sudin & Ahmed-Kristensen, 2011). Reflection is a conscious and rational action that can lead to reframing the problem when the frame is not satisfactory, making new moves or attending to new issues (Valkenburg & Dorst, 1998). As such designing can be seen as an iterative process of these learning cycles (propose, experiment, and reflect) until a satisfactory solution is reached (Lawson & Dorst, 2009). Figure 2.3 below illustrates this process.

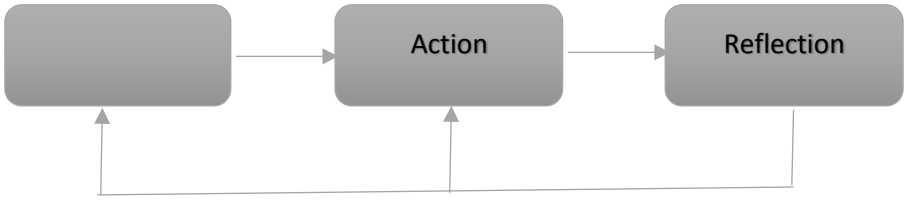

Figure 4: Schon's reflection model

(Adopted from Schon (1983) The Reflective Practitioner: How Professionals Think in Action.)

Although the cycle is presented as a linear process, the reflective practice is iterative and sometimes ad hoc. In a design process reflection practice can be seen as an iterative learning cycle involving designer proposing, experimenting and reflecting until a satisfactory solution is reached (Lawson & Dorst, 2009). As a result, reflective practice often gives new insight into the problem, which might cause changes to the problem definition and its solution space. Through reflection both the design problem space and the solution space evolve together. Therefore it may be unclear when to stop this cycle and shift to creation of the solution. This is against the backdrop that design problems are essentially wicked and unique, and can therefore be explained in numerous ways (Rittel & Webber, 1973), and their proposed solutions are highly dependent on both the context and the situation (Dickerson & Mavris, 2010; Shafaat & Kenley, 2015).

Through reflection designers gather relevant knowledge about the problem they are working on. They can also use this information to evaluate the route for reaching better solutions. In collaborative design we may view the *See – Moving – See* cycle as an example of how designers participating in teamwork reflect on each other's work from different viewpoints, as they

struggle to align their different perceptions on the design problem they are working on. As the designers look at a problem from different angles, they bring together insights which help them to clear their differences and build a common understanding of the problem. In a multidisciplinary design team invaluable ideas came from the unique expertise and specialisation among the members of the team (Valkenburg & Dorst, 1998).

2.2.1.3 Design as a social activity

Although the technical rational model sees design as concerned with technological artefacts and knowledge, it is largely carried out by people from diverse disciplines working in teams (Radcliffe, 2014). Even when an individual works alone on a design project, the individual adjusts his or her actions to society's expectations of what the designer is supposed to do (Brown & Duguid, 2000). Designers are entangled in society in the sense that society influences their behaviour, whether they like it or not. As such engineering design can be viewed as a social activity (Brereton, Cannon, Mabogunje, & Liefer, 1997) – a process that is a deeply human activity (Petroski, 1982). Design can be envisaged as being socially constructed, as design work can be understood only in the social context in which it is produced: "It is through the daily interactions between people in the course of social life that our versions of knowledge are fabricated" (Burr, 1995, p. 4). For designers, what they design and what they know about design is a result of their social interactions. Designs are given meaning by the social world, and in the professional setting designs are evaluated by peers, managers and clients. In the educational studio the judgements made by the designers' peers, tutors and examiners are critical to shaping of the design solution created by the student designers. The social dimension of design is further revealed when we consider that design decisions are not exclusively influenced by discussions held in formal meetings or the correct use of design principles, but it is also greatly influenced by the casual interactions and discussions that take place informally throughout everyday work (Larsson, 2005). For example, during the course of a design project student designers receive some advice from their colleagues as they meet them, and can sometimes overhear various stakeholders making comments on aspects that affect their designs. Such social interactions are key success factors in collaborative design (Bucciarelli, 1994).

It can be argued that design is framed by the social world, and it is therefore impossible to objectively interpret the nature of design specifications and artefact descriptions without an

understanding of the social setting where they were created (Minneman, 1991). When we look at it from this viewpoint we can be in a position to identify the various elements of the social that contribute to an effective design process. For example, in this study my aim was to collect empirical evidence that I could use to determine the role played by Web 2.0 technology in a collaborative design process. Web 2.0 technology provides a social interaction space where the technical and the social process of the design process are often inextricably intertwined.

The argument here is not to say that social activities are additional to design, but that they are in some way constitutive of the design process. In other words, design would not be carried out effectively without the social processes inherent into the design process. From this viewpoint engineering design is not seen as a purely technical activity, but is rather a highly social process. Ultimately the technical artefacts are designed to satisfy human needs and purposes, and the design process and its activities involve intense communication and interaction between individuals and groups in complex social settings.

2.2.1.4 The social network perspective

The social network view of design is an emerging perspective to design where the design process is viewed as a cyclical social process in which the designer generates work that is evaluated and adopted by other designers and the wider creative environment. In order to extend our understanding of the social view of design to the social networking view, we need to understand design as socially constructed within a social network of ties and relationships. Sosa and Gero (2005), acknowledge this connection between a social model and social networks:

> Social spaces are also characterised by ties, i.e., linkages between nodes in a social network. These links determine what adopters (nodes) have contact with each other. The strength of social ties refers to the likelihood that nodes in the social network are maintained over time. Strong ties are characteristic of resilient social relationships such as kinship or friendship, whilst weak ties characterise temporary social networks such as school peers or travel acquaintances. In networks with strong social ties, adopter agents maintain contact with each other over longer time periods, whilst in networks with weak ties adopter agents constantly change contact with different neighbours.

Basically this design perspective proposes that in any given design process, designers exist within a network of creativity that is social in nature and socially constructed (Joel, 2011). It is believed that designers work within a social context, and this constitutes actors and individuals

with a social connection and relationship to each other. Users and other external actors are equally important social influences on the design process. From this perspective the design studio can be considered a social network of actors (designers) relating to other actors in various ways.

The essence of this thesis is to illuminate the role of Web 2.0 in collaborative design. Web 2.0 by definition is a social network that exists on Internet websites where millions of people share interests on certain disciplines, and make available to members of these networks various shared files and photos and videos, create blogs and send messages, and conduct real-time conversations (Joel, 2011). Web 2.0 networks, for example Facebook, Twitter and MySpace, are described as social because they allow communication among friends and colleagues. In design work these networks are a source of various influences, ranging from inspirational idea generation to pragmatic networks that support the marketing of a new product. However, the challenge presented by this design model is its heavy dependence on the social as the determining factor in shaping the design process. In this view, the communication technology is only taken as a medium of information transmission and is assumed to have no influence on how the design process is constituted. Nevertheless, the affordances provided for by Web 2.0 technology position this as more than a mere medium of information transmission. Web 2.0 technology has the ability to provide a design space where designers can engage in a dialogue that can shape how the design process can be carried out in practice.

2.2.1.5 Design as an actor network

As I have argued above, the social network perspective to design seems to give a priori pre-eminence to the social in determining the course of the design process and how designers reach the solution to the design problem. However, Bucciarelli (1984, p. 187), points us to the need to strike a balance between the social and the technical dimensions in design activities, when he notes that:

> (…) different participants in the design process have different perceptions of the design, the intended artefact, in process. What an engineer in the Systems Group calls an interconnection scheme, another in Production calls a junction box. To the former, unit cost and ease of interconnection weigh most heavily; to the latter, appearance and geometric compatibility with the module frame, as well as unit cost, are critical.

Therefore social activities cannot be separated from the technical artefact resulting from the design process. These two are intertwined in the:

> (…) meetings that produce the specifications; the discussions around rough calculations and sketches that create understandings among the participants; the arguments about interpreting test results and prototype qualities that contribute to 'feel' and 'intuition' about aspects of the design; and the debates about whether the design is 'done', if the specifications have been 'met', and if the result is 'good'. (Minneman, 1991, p. 63)

Design process therefore is an entanglement of the social and technical issues that need to be aligned in order for us achieve our goals. The task of design then becomes more of a matter of getting everyone involved to agree on the most significant issues and to shape consensus on what must be done next. This presents design as a process resulting from the connection of various things into a network of action. To demonstrate the '*networky'* nature of design Yaneva (2009) notes that

> Design connects in very specific ways. Whenever designers work on a project, stage a presentation for a client or present a mock-up, or when we, as users, use and misuse artefacts or find ourselves entangled with the environments and networks of design, we deal with an attachment that is typically the nature of design.

Design as an actor network entails a series of translations that include but are not limited to: the definition of the design problem, specification of requirement and formulation of possible solutions, agreement on chosen solutions, and adoption of products and services by users. As Ciuccarelli and Valsecchi (2007), point out, it is a knowledge transfer process based on tools, from pencils to cognitive maps. The knowledge gradually comes into shape as the design artefact comes into sight. The design process should be understood as a flowing stream of translations which can either reinforce or change the course of the design process. The reconfiguration of the design process through a series of these translations should be viewed an as ongoing process of negotiating among the designers and other actors. In this sense, a design project resembles more a complex ecology than it does a static object.

In such an environment, the design process can no longer be seen as the work of a single actor, but as a network of all contributing actors, regardless of their importance or size (Schneider, Richter, Petzold, & König, 2010). A network in a design situation refers to individuals and their materials, including their tools, as being continually involved in processes of sharing and being able to organise into creative communities of practice and knowledge sharing (Ciuccarelli & Valsecchi, 2007). In a design project the non-human actors are also holding ground for collectively negotiated design solution. As such, in a Web 2.0- facilitated collaborative design process there are heterogeneous human and non-human actors that act

differently within the network and influence one another mutually. Besides the architect, expert planners and developers, one can also regard design objects, design tools, environmental conditions, laws, norms and institutions as contributing actors in the design process (Schneider, Richter, & Petzold, 2010; Schneider, Richter, Petzold, et al., 2010). A special note on the concept of actors is the assumption that there is a coexistence or symmetry of human and non-human actors who mutually ascribe one another's actions. As proposed by ANT theorists, the so-called micro-actors such as individuals and their tools should be treated equally together with macro-actors such as institutions and organisations (Schneider, Richter, & Petzold, 2010). While their differences are not denied, it is the construction of networks that should help us to uncover their differences and their available capacities and influence.

ANT calls us to view a Web 2.0-facilitated collaborative design process as a process constituted by a heterogeneous set of human and non-human actors that act differently within the network and influence one another mutually. Considering both human and non-human actors in the design process as having equal opportunities in shaping the design process has the advantage that the divide between the 'subjective' and 'objective' could be abandoned (Yaneva, 2009). Yaneva (2009, p. 283), illustrates how the subjective/objective divide is reflected in the way a define artifact for example, can be defined:

> "Presently, the object is grasped in two different ways: either through its intrinsic materiality, (something that would define it as material real, objective and factual); or through its more aesthetic or "symbolic" aspects (that would define an artifact as a social, symbolic, subjective and lived."

However, some post-modernist design theories such as Yaneva (2009, 2013), and Latour and Yaneva (2008), argue that adopting an ANT view to the analysis of design helps us escape this modernist division as it gives us tools to show how the non-human (materiality) from one side and the human (morality, ethics, politics), from the other, coalesce in the design process (Yaneva, 2013). When we observe how the designers engage with technology, including the various computers hardware, software, the internet, specialised design tools, consulting with specialists and the users; noting how these shape and influence the designers' actions, we can then begin to appreciate that design is certainly a process of enacting the social. In this regard, Yaneva (2009, p. 283), suggests that design research should therefore "engage in analysis of how materially from one side, and morality, ethics, politics from the other, are to coalesce in design"

Furthermore, my argument in this thesis is that such a process, which is constituted by a heterogeneous set of actors including human and non-human is bound to be so complex and full of surprises to the extent that it cannot be represented in linear approaches such as the prescriptive models of the rational paradigm. Employing an ANT approach to the analysis of the design will show that "design embraces a complex conglomerate of many of surprising agencies that are rarely taken into account by design theory." (Yaneva, 2009, p. 283). For example, the model can reveal the extent to which designers are attached to non-human actors in a mutual relationship.

An ANT framework for research entreats us to consider the non-human things involved in the process, for example design documents/sketches, drawings and diagrams, as co-actors with humans in the interactions that constitute the design process. These things are seen as part of the actants enlisted into the heterogeneous network, which work together to assemble a solution to the design problem. Designers can hardly conceive any new object or artefact without being assisted by mediators such as drawings, tools, models and other devices used to represent design ideas during the design process (Yaneva, 2009). These networking tools that mediate the designers' everyday information and knowledge activities provide an easy and fast platform for participation by actors in generating content as well as enabling new relations among the actors.

The growth in popularity of the actor network perspective to design is a result of the evolution in the World Wide Web which resulted in the introduction of Web 2.0 technologies. The Web 2.0 network paradigm refers mainly to content creation and sharing relationships as well as cooperation practices among web users. Web 2.0 technology has brought with it the phenomenon of digital communities that are strictly connected with the tools for managing knowledge (Ciuccarelli & Valsecchi, 2007). Web 2.0 networking tools are technologies that allow users to act on and experience knowledge, which is consistent with the notion that sharing increases knowledge and that design activity involves sharing expertise (Ciuccarelli & Valsecchi, 2007).

This study sought to highlight the assemblage of relationships in a Web 2.0-technologies facilitated collaborative design process in order to illuminate the role played by Web 2.0 technologies in the complex weave of socio-technical actors involved. To accomplish this task, I appealed to ANT resources to help me explore the connections or associations between the

human and non-human actors involved in the Web 2.0 collaborative design process. I used the selected ANT resources to trace the connections and examine them in order to illuminate the assemblage of the collaborative design networks which emerged. So instead of the researchers worrying themselves with trying to analyse the design process from predetermined structures and isolated activities by individual designers, they should expend their energy on trying to grasp the erratic and dynamic relationships that are established among all the actors involved in the design network, and how they shape the way design is carried out in practice.

ANT gives design researchers the resources to trace these painstaking ways in which designers interact during the course of the design process. Unlike most other design theories which are generally abstract and theoretical, ANT provides the researcher with a methodological framework that allows one to study the designers in action and generate rich data that allow them rich descriptions. These rich accounts of the design process can only be achieved when researchers trace the pluralities of the concrete entities in the specific spaces and times as they take place. Yaneva (2009), points out that only when design studies are carried out from this perspective are findings able to contribute to our understanding of the concept of collaborative design. I will develop this argument in the last part of my literature review, when I trace the relationship between ANT, Web 2.0 technology and collaborative design research.

2.2.2 Summary

In this part of the literature review I traced how the concept of design has evolved from a purely rational process of problem solving, which dominates most discussions on design practice in most disciplines, including engineering. This model is based upon the conceptualisation of the design process as a staged, linear process. The logic behind this model is that the design process involves problem decomposition, where the design problem is broken down into its components, which are easily interpreted to allow designers to create a solution to the problem through some technical-logical rationale. This view has been criticised for failing to adequately account for the full richness of what designing is to an engineer. It has been argued that design cannot be compared to pure sciences like physics, because whereas scientists study the world as it is, designers create the world that never has been (Simon, 1969). As a result, a social view of design was proposed (Bucciarelli, 1984). This was a result of the general shift in sociological perspectives on science which questioned the myth of the linear scientific progress and its myth of scientific objectivity in research methods. This saw a shift in the conception of design

moving away from technical rational view of design, which prescribes one right way of carrying out design. The overall contention therefore, is that neither the technical-scientific rationale nor the social models of deign adequately capture the dynamics that constitute collaborative design.

As such, I suggest ANT as a new language of design. ANT views design a complex process that is constituted by a heterogeneous set of entities that work together to align different design interests and translate them into a satisfying design solution. ANT embeds the social and technology into the same network of actors and provides a view that can embody the value of technology such as Web 2.0 in collaborative design. Extending ANT to the field of design research requires mobilising this method's persistent ambition to account and understand the role played by the heterogeneous actors that constitute the design network. This means we must understand the process as a dynamic network which is created by various actors working together. As such, in the last part of this literature review chapter I trace the relationship between Web 2.0 technology and collaborative design, with the hope of finding an entry point into an inquiry into the role of Web 2.0 technology in collaborative design.

PART C: TRACING THE LINK BETWEEN ANT, WEB 2.0 AND COLLABORATIVE DESIGN

2.3 Introduction

As a result of the advancements in the semantic web and Web 2.0 technology in particular, the world is becoming increasingly more connected. Most of the interactions that take place within the Internet today hinge on the use of Web 2.0. In actual fact, it is the multiplicity of applications (apps) associated Web 2.0 that has resulted in the increase in our embroilment with each other. Nevertheless, there can only be a connection between two entities when there is action in the link; without action a connection is simply a metaphysical link, which does not have any tangible meaning. However, Web 2.0 allows for more complex interactions and communication patterns that give action to the connections among entities in the world As a result some scholars have seen it as the main vehicle of a major shift in the "new settings to the informational landscape of organizations" (Depauw, 2009, p. 1) and a "social movement" (Birdsall, 2007, p. 1) that has been able to unlock web realities that were not achieved during the previous ages of the Internet. As our actor networks increase in their complexity, it is therefore important that we advance our knowledge of how best we can leverage these technologies to improve our social, educational and professional experiences. As I have argued in Part A of this literature review, ANT is a ready-made blueprint that is available to tackle this issue. Therefore in this part I review literature that can help us understand Web 2.0 technology as actors that mediate connections among entities in the world of action. In section 2.4 I give a broad definition of the term Web 2.0 as my starting point in understanding the technology.

2.3.1 Defining Web 2.0 technology

The notion of Web 2.0 still mystifies many. It has been described as a "curious term, laden with uncertainty" (Allen, 2008, p. 2) as there are many ontologically non-compatible and competing definitions arising across a wide variety of evolving literature streams. This muddle is owing to the fact that Web 2.0 is used to describe "ideas, behaviours, technologies, and ideals all at the same time" (Allen, 2008, p. 2). Generally Web 2.0 is viewed as a grassroots term widely used to describe the online phenomenon resulting from newly evolving Internet technology infrastructures (O'Reilly, 2005). The first definition of Web 2.0 was given by O'Reilly (2005, p. 13), who is believed to be progenitor of the term:

> (…) the network as platform, spanning all connected devices: Web 2.0 applications are those that make the most of the intrinsic advantages of that platform: delivering software as a continually-updated service that gets better the more people use it, consuming and remixing data from multiple sources, including individual users, while providing their own data and services in a form that allows remixing by others, creating network effects through an 'architecture of participation', and going beyond the page metaphor of Web 1.0 to deliver rich user experiences.

O'Reilly's definition views Web 2.0 as more than providing users with simple application tools. According Rossi (2010, p. 17), Web 2.0 gives us , "complex applications like Google *(which)* are never sold or packaged but delivered as a service that undergoes continuous improvement during their lifecycle". Furthermore, Web 2.0 is viewed here as not only the web-based applications, but the development and delivery of web services that give users control over how the users can participate in a network.

From O'Reilly's definition we can identify at least four core principles of Web 2.0 which are crucial to this study: (1) the web as a platform, (2) harnessing of collective intelligence, (3) prominence of what is shared (data) in shaping networks, (4) software above the level of a single device, and (5) the rich user experiences. Clearly Web 2.0 is a new era of the web that is not only represented by merely new technological features (Cormode & Krishnamurthy, 2008), but is distinct and involves the technological, structural, and social dimensions of the web (Cormode & Krishnamurthy, 2008, p. 1). According to Rossi (2010, p. 17), Web 2.0 "addresses more than a simple technological advancement in web-related tools." Rossi (2010) views Web.20 as a social construct which has no easily identifiable elements because both the social and technological dimensions of the technology are interweaved more than ever. To illustrate this point Rossi (2010, p. 17), notes that "users have become active on and through technology, while the technology is designed for users to easily create, publish and share content as well as connect to other users." As these tools have been developed to facilitate interaction among ordinary people, they have come to be known as the "social media" or "social web".

However, this interlacing of the social and technical dimensions of Web 2.0 has tended to land itself in opinions that are driven by different theoretical viewpoints. For example, traces of both technological and social deterministic thinking are noted by Rossi (2010), when she suggests that on one hand, it may be argued that the use of these new tools would result in the

development of some specific social behaviour among the users. On the other hand Rossi (2010) suggests we may argue that the increased degree of sociability afforded by the Web 2.0 tools may result in a more empowered user who has full control of the media.

The classification of some Web 2.0 technology tools, such as Facebook, Twitter, and MySpace, as social networks is a result of such views. A definition of social network sites proposed by Boyd and Ellison (2008, p. 2) further illuminates this argument:

> [...] web-based services that allow individuals to (1) construct a public or semi-public profile within a bounded system, (2) articulate a list of other users with whom they share a connection, and (3) view and traverse their list of connections and those made by others within the system. The nature and nomenclature of these connections may vary from site to site.

It is such views of understanding the relationship between technology and society that this study seeks to challenge using the ANT as a theoretical framework. In the next section I carry out a search for a theoretical framework that could be used to better understand the role of Web 2.0 technology in collaborative design.

2.3.2 A search for a theoretical framework for studying Web 2.0-facilitated collaborative design

There are two main viewpoints that have dominated the explanation of the relationship between society and technology, namely technology determinism and social constructivism. In the search for a theoretical framework to understand the role of Web 2.0 technology in collaborative design I explored these two approaches, only to demonstrate how ANT could theoretically include not only the two poles of determinisms but also most of the approaches that could fall under the label of social constructivism (Elbanna, 2009). In a nutshell, "technology determinism argues that technology determines the nature of society and drives it along a predetermined path" (Elbanna, 2009, p. 2), whereas social constructivism believes in the power of the social in shaping technology.

Although both viewpoints are valuable in providing a specific lens to view the relationship between technology and society, my contention is that they do not provide an open and unbiased explanation of the intertwined relationship between the two. Each of these two dominant theories gives a priori prominence to either technology or society in shaping the

social. In this section I provide a snapshot of these viewpoints so that I can reveal how ANT could theoretically include both in explaining the relationship between technology and society.

2.3.2.1 Technology determinism

In general, determinism is a view which "holds that everything is caused (determined) by a sequence of previous conditions and events, operating with regularity and, in principle, predictability" (Pannabecker, 1991, p. 2). As such, technology determinism is a viewpoint that suggests that technology determines the nature of society and drives it along a predetermined path (Elbanna, 2009). This viewpoint argues that "a given technology imposes certain social and political characteristics upon the society in which it is applied" (Heilbroner, 1994b, p. 7). Thus, technology is given the power to dictate patterns of social relations in society. The hardliner view of determinism views technology as "a natural, independent force that has the power to shape society and social relations" (Elbanna, 2009, p. 2). In their analysis of this viewpoint, Sturken, Thomas, and Ball-Rokeach (2004) note that:

> the transformative power awarded to new technologies is directly related to the idea that technologies arise not of the world in which we live but as a force that comes magically from elsewhere, a force seemingly outside of social and political influences

However, some authors in technology determinism have found it difficult to eliminate completely the role of society in the relationship between technology and society. For example, Heilbroner who embraces the technology determinism stance in his works, gives a note of caution: "... even where technology seems unquestionably to play the critical role, an independent 'social' element unavoidably enters the scene in the design of technology" (Heilbroner, 1994a, p. 342). He rather suggests that "the machine will reflect, as much as mould, the social relationships of work" (Heilbroner, 1994a, p. 61). In other words, he suggests that we practice a 'soft determinism' to explain the influence of technology on social relations. This is perhaps because as Elbanna (2009) argues, Heilbroner's version of determinism views technology as a mediating factor rather than the deterministic power to shape society.

2.3.2.2 Affordance theory

One deterministic theory is Gibson's affordance theory. According to Conole, Galley, and Culver (2011, p. 121), Gibson's affordance theory relates to "the perceived and actual properties of a thing, primarily those functional properties that determine just how the thing could possibly be used". However, Gibson is a bit more cautious when defining affordance. In

his definition, Gibson (1979, p. 119), cautiously defines it as "All 'action possibilities' latent in an environment … but always in relation to the actor and therefore dependent on their capabilities". When applied to technology these affordances are latent in the technology's environment (Wright & Parchoma, 2011). These affordances are objectively measurable and independent of the individual's ability to recognise them, but their enactment is always in relation to the actor (Gibson, 1979). Application of this concept to studying the role of Web 2.0 technology in collaborative design sounds promising, since the theory seeks to describe the interconnection between technology tools and users. However, Gibson does not provide a full explanation of the nature of this relationship. Consequently, an attempt to appreciate the inherent affordances of any given technology leads to a logical impasse, and the act of measuring affordances thus "becomes speculative rather than analytic" (Oliver, 2005, p. 401).

Another challenge with the affordance theory is its presupposition of functions of technology. As Pea et al., cited in (Borgeman et al., 2008) argue, what technology can do in society cannot be predetermined, but there is some co-evolution of tools and users over time. Therefore what technology can do can never be fixed, because the interactions and patterns of user behaviour are not static. According to Conole et al. (2011, p. 121), "This co-evolution depends on both the inherent affordances of the tools and the characteristics of the users (i.e. their skills base, personal preferences and beliefs, and the context and culture within which they are interacting with the technologies)" . While this has always been the case, arguably the pace of co-evolution has increased dramatically in recent years, particularly around use of Web 2.0 tools. With the advent of Web 2.0 technology on the internet we have experienced a major shift in the way we can use the web. Users have been transformed from being consumers of web content to become content developers in their own right. The proliferation new and free user friendly content development tool which have transformed the Web from a static-content to a more dynamic and user-generated content Web. Literally, everyday a new Web content generating tool is introduced to allow user to contribute content on to the Web. For design learning, Web 2.0 technology has brought in tools that can allow student designers to interact and share ideas and peer critiquing each other using social media such as Facebook, tweeter, and blogging tools among others. Web 2.0 has also other content generating tool that can allow students to express their design ideas in audio (e.g. UJAM), videos (e.g. CamStudio), pictures (e.g. Picasa) and 3D models (SketchUp). These tools are premised on user friendliness, adaptation and remixing to allow for flexibility in both their usage and the content they provide to the users.

2.3.2.3 Social constructivism

An attempt to look at the role of technology from an impartial and relativist approach is made by employing social constructivist theory. Social constructivism is sometimes used in a narrow sense to refer to SCOT (Bijker, 1987; Pinch & Bijker, 1987). In a broader sense the term includes social-shaping approaches (MacKenzie, 1990a; MacKenzie & Wajcman, 1985) as well as the actor-network approach (Callon, 1987; Latour, 1987). From a social constructivist point of view technology is seen as having some interpretive flexibility. This implies that technology has no objective, fixed properties. Technology derives its functional, social-cultural properties and technical content, that is, the way it works, from its interaction the surrounding context. As Brey (1997) aptly puts it, facts about a technology are not objectively given by the technology itself, but determined by the interpretations of relevant social groups. Viewed from this perspective technology is therefore socially shaped or socially constructed; that is, its properties are largely if not exclusively determined by the interpretive frameworks and negotiations of relevant social groups (Brey, 1997). In the conduct of research social constructivist approaches typically employ a principle of methodological symmetry or methodological relativism (Brey, 1997, p. 3). This principle implore the researcher to remains impartial to what constitute the real properties of the object being analysed (Brey, 1997).

Social constructivism questions the idea that technology leads to (determines) social reality and not vice versa. According to Lawson (2007, p. 8), the role of technology in shaping technology is viewed as "genuinely contingent and not reducible to some inner technological logic". Basically, social constructivism challenges the assumptions of technology determinism that the role played by technology can be seen as fixed, or on some monotonic trajectory. Instead, emphasis is placed, usually by drawing attention to a series of case studies;

> … upon the contingent nature of technical change and on how technology is 'shaped', especially by different social groups in the process of settling a range of technological/ social controversies and disagreements" (MacKenzie & Wajcman, 1985, p. 14).

Consequently, the role of technology cannot be analysed as following a fixed, unidirectional path, and cannot be explained by reference to some inner technological logic. Instead, Brey (1997, p. 58), argues that "the role of technology is best explained by reference to a number of technological controversies, disagreements and difficulties that involve different actors".

However, a common misconception of social constructivism by many is to say that technology is socially constructed if it is developed to be used by people or to meet some human need or solve some human problem. Almost all technology is designed with these things in mind, and therefore this is not what social constructivist theories mean by social construction. Instead it is a way to think about the meanings a technology develops in use. For example, STS scholars regard technological artefacts as having 'interpretive flexibility', implying that the same technological artefact can be seen in very different ways by different people, and thus becomes in effect different artefacts. Their argument is that although technology developers often inscribe certain use patterns in the design of the technology, users have the freedom to adopt, reject, or modify the way they can use the technology, sometimes coming up with a completely different way of using it. This view of technology has been applied in much STS research to understand the sociology of scientific knowledge, using the SCOT approach. This approach strongly upholds the principle of symmetry, by deliberately avoiding all reference to the actual character of technology in its analysis (Brey, 1997). The role of technology is instead explained by reference to processes of interpretation, negotiation and closure by different actors and social groups, and viewed as a genuine social construction of inherent properties, powers or effects are attributable to technologies themselves (Brey, 1997).

2.3.2.4 ANT

Having considered the problems with the concept of a relationship between technology and society from the two extreme positions (the deterministic and the social constructivism perspectives), I now turn to explore ANT as a potential analytical framework for the analysis of the relationship between technology and users. In this study I propose the ANT as the most appropriate theory to explain the role played by Web 2.0 technology in collaborative design.

The criticism levelled against social constructivism is that it gives special preference to social elements and interpretation processes in its explanation of the relationship between technology and society. The technical elements such as technical devices or artefacts are forbidden from being explanatory elements. My reason for proposing ANT is that it has potential to illuminate the role of Web 2.0 technology in a dynamic process such as collaborative design, in that it employs a principle of generalised symmetry that gives any element that is part of a heterogeneous network of entities a similar explanatory role (Callon, 1987; Callon & Latour, 1992; Latour, 1987b). The inclusion of non-human actors is a major attraction of using ANT to understand the use of Web 2.0 in a networking process such as collaborative design.

According to Conole et al. (2011, p. 120), this enables design researchers to "foreground technological mediating artefacts and to describe their interactions with other actors within the networking context".

Furthermore, ANT is relevant to our understanding of Web 2.0 technology because of its focus on network connections instead of on the physical distances involved, which arguably is the same metaphor that is most relevant to Web 2.0 technology-facilitated communication and interaction environments (Conole et al., 2011). ANT's principle of symmetry, which implores us to use the same framework of analysis for both humans and nonhumans as actors in a network will help eliminate the artificial divide that imposed on these actors by many positivist design researcher. According to ANT, these actors and their networks are mutually constitutive. This implies that there is no actor without action and that relationships among actors and the network are built on the mutual influences and intermediaries that actors exchange between each other.

Applying an ANT analysis in this study can provide a detailed description of the way in which the Web 2.0 opens standards and applications such as blogs, wikis, multimedia-sharing services, content syndication, podcasting and content-tagging services interact (Naidoo, 2012) in a network such as a Web 2.0-facilitated collaborative design. ANT can be deployed to effectively tease out the various sets of relationships that must be illuminated in order for one to come to terms with the role of web technologies, together with human actors, in constituting the collaborative design process. ANT also refers to translation, which is the power of actors to influence the network connectivity properties. This is particularly noticeable with Web 2.0, given the ease with which users can get across their points of view. A core idea behind the Web 2.0 paradigm is the user's ability to contribute information onto the web from multiple applications in a simple manner that many non-technical users now handle daily. In fact, according to Shum (2008), the phenomenal increase the usage of Web based applications such as Google Maps, YouTube, Flickr and Slideshare is in part due to the ease with which users can apply these technologies in their daily work. Using the theory of translation it should be possible to trace the role of Web 2.0 technology, like any other artefact, back to a set of problematisations. In this regard, the translation process describes the emergent outcome of technology meeting social practice. This analytical framework can illuminate the mediation role of Web 2.0 as well as any related socio-technical systems in a heterogeneous network such as collaborative design.

Furthermore, ANT's associative ontology relates more to the networked nature of Web 2.0 connectivity, for various reasons (Mould, 2008). Firstly, ANT's focus on practice and action as the force behind the network aligns very well with the performative aspects of Web 2.0. For example, if we consider Twitter and Facebook, the networks formed by people following each other only manifest when those people make their contributions, that is, when they actually post something on to the platform. The many spam followers and users who create accounts just to see what it is all about, and are quick to lose interest and stop contributing, create a 'hInternet' of defunct connections which are not acted upon. These dead links cannot be considered part of the networks from a performativity point of view, because they do not 'effect' the constitution of the network (Naidoo, 2012).

2.3.3 Web 2.0 from the ANT point of view

My point of departure in this section is to provide an understanding of the term Web 2.0 from an ANT perspective. My aim is not to come up with yet another definition – in any case, from an ANT perspective definitions are not fixed, because there is no fixed object in the social but only object formation (Latour, 2005). Therefore in this section I carry out a critical analysis of the definitions given in the literature in order to come up with an in-depth and comprehensive explanation of the term Web 2.0 through the ANT lens. My contention is that ANT, which is the theoretical framework guiding the conduct of this study, is the most appropriate analytical tool to provide a lens to understand and analyse complex phenomena such as Web 2.0 virtual design space (Depauw, 2008). However, I am not going to reinvent the wheel, because some work has already been done in defining the term Web 2.0 from the ANT perspective (Beer & Burrows, 2007).

Although it is widely accepted that Web 2.0 is technology driven, there has been recent widespread agreement on the fact that the benefits of the technology come from the use that is made of these tools. As a result, many scholars have suggested a broader perspective of Web 2.0 than the tools and practices view. Some have described it as an online trend or as a state of mind, an attitude (Birdsall, 2007) or even a philosophy (Hoegg, Martignoni, Meckel, & Stanoevska-Slabeva, 2006). When applied to Web 2.0-facilitated collaborative design, tools per se do not shape the collaborative design process, but considering Web 2.0 technology as a set of uses highlights the benefits and major applications of and for the set of tools (Depauw,

2008). This view gives Web 2.0 its significance as a trend and confirms the need for a theoretically grounded concept. Such a broad view of Web 2.0 is shared by many ANT-oriented scholars, including O'Reilly (2005). For example, according to O'Reilly (2005), Web 2.0 technology was envisioned to function as a core set of principles and practices that are applied to common threads and tendencies observed across many technologies. This view is further illustrated by the Wikipedia definition, cited in (Depauw, 2008, p. 6):

> Web 2.0 is a trend in the use of World Wide Web technology and web design that aims to facilitate creativity, information sharing, and, most notably, collaboration among users. These concepts have led to the development and evolution of web-based communities and hosted services, such as social-networking sites, wikis, blogs, and folksonomies.

This definition suggests a structure of Web 2.0 with three major areas of focus, namely: principles and practices, threads and tendencies and technologies (tools). O'Reilly describes these areas as the main dimensions of Web 2.0 (Depauw, 2008). Figure 5 illustrates these dimensions.

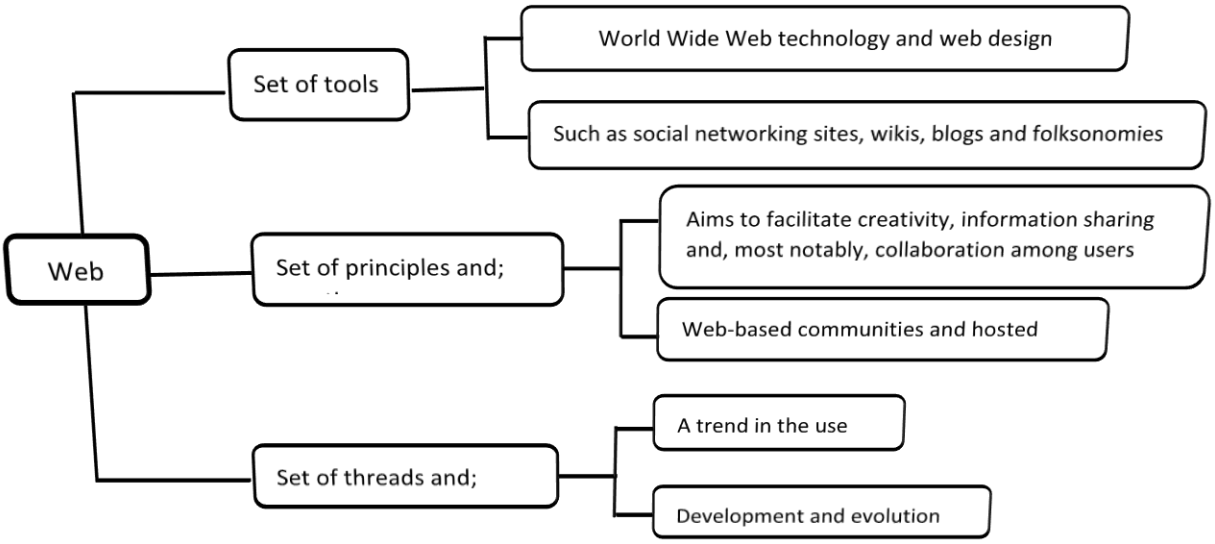

Figure 5: Web 2.0 from the ANT perspective

As a set of tools, Web 2.0 is seen as the 'material tools' or the actual technologies, as in the physical format of tools or gadgets (Depauw, 2008). This view seeks to explain the technical architecture and the utility of Web 2.0 technology, regardless of their implications for the users or the field of application. In ANT terms, Web 2.0 as a set of tools implies that the technology can be considered as a set of intermediaries. As Depauw (2008) puts it, "Indeed, they order and form the medium of the network they describe". Web 2.0 as a set of principles and practices relates to the less tangible aspects of the technology, which include the actual practices on

content, for example transformation and sharing of information and the interaction among users as they collaborate in order to meet common goals. This dimension puts the user at the forefront; thus in ANT terms this dimension is in the realm of actors. In particular, it is ANT's focus on practice and action as the formulating power of the network that positions it to explain the performative aspects of Web 2.0 (Mould, 2008). Since according to ANT actors define one another by means of the intermediaries they put into circulation, this dimension therefore suggests that we go beyond the description of intermediaries and points us to entities (human or non-human) that assume authority in activating intermediaries (Depauw, 2008). Web 2.0 as a set of threads and tendencies presents Web 2.0 technology as more than a technical or practical phenomenon (Depauw, 2008). This view emphasises the impact of the principles and practice dimension on a broader scale, taking Web 2.0 as an object and characterising and qualifying the technology from this view. This, according to ANT, is an attempt to 'black box' the technology by describing it as a set of effects.

To conclude this discussion, ANT allows me to define Web 2.0 networks as effects initiated by interacting actors, who mobilise intermediaries that stabilise the network. In this view, Web 2.0 can be defined as a set of threads and tendencies, initiated by a set of principles and practices that are mobilised through a set of tools (Depauw, 2008). Figure 6 illustrate these concepts.

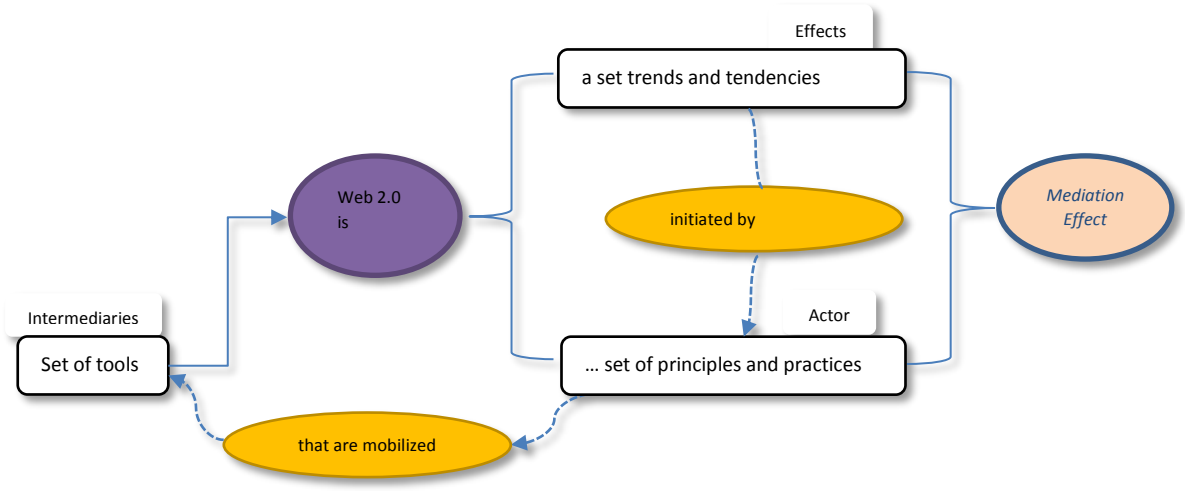

Figure 6: Web 2.0 as viewed from an ANT perspective

As such, we can define a Web 2.0 technology-facilitated collaborative design network as more of a *leaky black box* (Callon & Latour, 1981a) than a black box, since it is a network that is shaped and reshaped by the effects of interacting actors and their intermediaries (Depauw, 2008). For example, the enrolment of new actors and the departure of existing actors or changes

in associations can cause the collaborative design network black boxes to be opened to reconsider its contents (Tatnall, 2009). As a result of the performativity nature of Web 2.0, the network is only temporarily stabilised or black-boxed through the alignment of interest among the actors involved in the process.

2.3.4 Mapping the translation of Web 2.0 technology into the design process

In this section I review literature that traces the translation of Web 2.0 technology into the design studio and reflect on the role it has played in transforming and shaping how collaborative design is constituted and carried out in practice. As demonstrated by Schon's studies, the design studio has been the traditional space where design was taught and practised. The design studio is a physical space for a shared, prolonged, and communal activity that enables social interaction and experiential learning to take place (Pekta, 2015). It is essentially a shared environment where students are assigned design problems to solve under the guidance of a tutor through a process that engages them in a reflective practice and dialogue with the design situation (Schön, 1983). The ever-increasing complexity of design problems coupled with the developments in ICT has rendered the traditional design studio inadequate to facilitate the teaching and learning of design that is commensurate to current developments. Today's learners are approaching a state of nomadic ubiquity (Attali, 2011), with the ever-increasing developments in optical fibre, Wi-Fi, 3G and 4G mobile technologies and their use in conjunction with a range of nomadic devices such as smart phones, tablets and laptop computers. These technologies have made their impact in the traditional classroom, and the design studio has not been spared.

The virtual design studio (VDS) emerged in the early 1990s, almost parallel with the advent of the Internet as the first attempt by design educators to respond to the changing nature of the object of design with regard to meeting the demands of today's design problems and the taste of today's learners in terms of design learning space. Whereas the traditional design studios "generally consist of a number of projects delivered in face-to-face mode on campus, based on sites that are accessible physically by students" (Ham & Schnabel, 2011, p. 4), VDS can be described as an online or networked design studio. A VDS can be defined generally as a type of studio that leverages the affordances offered by digital media and virtual environments to expand studio space beyond physical and time limits (Laiserin, 2002; Pekta, 2015). In other words, VDS is characterised by its ability to broaden the time and space boundaries, presenting opportunities for designers to design and communicate using computer-mediated and

computer-supported platforms. The introduction of the VDS has resulted in the evolution of a complex design landscape that attempts to respond to the changing landscape in design (Schnabel & Ham, 2013; Smithers, 2010).

For example VDS offers an extension of the design studio outside of the limitations of scheduled classes, something that fits in with many university students' work hours and nomadic lifestyles. Designers are able to represent processes and outcomes in digital forms that can be accessed anytime/anywhere through the Internet using both asynchronous and synchronous communication systems (Maher, Simoff, & Cicognani, 2006). Scholars who studied VDS design environments agree that the studios were established to allow action while physically distant. Other reasons are due to the dictates of the design (Achten, 2001), as a way of enhancing student communication (Schmitt, 1997), or for the desire to use digital communication (Kurmann, 1995) and other digital tools (Maher, Simoff, & Cicognani, 2000). As such, Schnabel and Ham (2014, p. 229) note that the "VDS has evolved as a learning environment that allows students in various locations to engage synchronously and asynchronously in design learning".

Although the developments in technology reported in VDS have had a big impact on the design studio, their dependence on hard and software skills as well as familiarity with the media and learning environment have limited their influence on how design is carried out in practice (Ham & Schnabel, 2011). The major challenge with VDS is that the virtual environments are created by simple asynchronous communications tools such as email and static posting sites, which do not allow the spontaneous real-time communication which is characteristic of collaborative design. In addition, the use VDS does not recognise social engagement as crucial or central to the overall process of construction of knowledge in design. It is for such reasons that some design researchers have raised the need for a constant revisiting of the VDS until such a point that we have a fully integrated studio where the borderlines between the realms of the designers, their tools and the mode of communication are dismantled (Ham, 2010; Mitchell, 1995). With the arrival of Web 2.0 technologies the only logical step to develop the VDS was to leverage the social and collaboration affordances of Web 2.0 technology (Schnabel & Ham, 2012). This technology has the potential to transform VDS into taking new directions that can address the shortcomings identified in past research.

As (Potts, 2008, p. 1) points out Web 2.0 technologies;

> "…are today used by professionals who want to see more unified, holistic experiences that will support collaboration, knowledge sharing, and information validation by participants across multiple systems."

Consequently, the social network VDS (SNVDS) became the successor of the VDS and has been integrated into design learning since 2009 (Ham & Schnabel, 2011). Web 2.0 technology has been introduced into the design studio for various reasons. For example, Ham (2010) and Schnabel and Ham (2013) note that Social Networks, a form of Web 2.0 technology, were first used in design studio learning as a means of engaging students in the architectural design process outside of the limitations of the University's Learning Management System. Owen et al., (2006) in Schnabel and Ham (2012, p. 399) point out that;

> "…ease of communication, leadership opportunity, democratic interaction, teamwork and sense of community are some of the improved aspects offered by Web 2.0 technology or social network as they are addressed in some sections of the literature."

From the above, it can be concluded that the integration of Web 2.0 into design learning can transform the design learning space and practice by facilitating student designers to engage with the design task anytime anywhere. Use of Web 2.0 has the potential to extend design practice beyond the conventional boundaries of time and space (Ham, 2010; Ham & Schnabel, 2011).

Thus, from an affordance point of view, Web 2.0 technologies bring a wide range of capabilities to the collaborative design process. For example, YouTube and similar applications can be used to change the face of design learning in a number of ways. In addition to their obvious function as a medium for submission and repositories of design projects assignments, the technology can be used to allow student to make design representation through videos, graphics and audio, in ways that have never been achieved by their predecessors. Thus, Web 2.0 technology, such YouTube could be used as a submission and presentation medium as well as an a design learning space for demonstrating the learning of other skills and proficiencies in technology required for the design project (Ham & Schnabel, 2011). Student engagement with YouTube as a medium of video offers a more dynamic mode of design presentation through its ability to enable high-quality sound, motion, voice-over and text to be integrated into studio projects. Significant potential exists here in future developments using multimedia in the design studio to overcome the problems identified above in relation to limited professional and

industry exchange within design studios. Due to the ease with which Web 2.0 technologies can be used, students are not taught video making, but use easy and freely available video-making programmes such as iMovie HD and Windows MovieMaker, which they can learn from countless tutorial videos posted on YouTube. This helps universities to overcome the skill training overheads essential for much application software used in a technical field such as engineering design. The adoption of Web 2.0-based applications can help resolve technical issues with regard to efficient and effective use of technology in design work.

Furthermore, Boulos and Wheeler (2007, p. 8) note that the use Web 2.0 "requires a low level of technical skills; anyone can publish and access content anytime, anywhere". This opens up opportunities for the creation of an open, democratic and transparent bottom-up communication system (Kolbitsch & Maurer, 2006). For example, in their study of Web 2.0-facilitated collaborative design projects between students and staff from Deakin University and students from Hong Kong, Ham and Schnabel (2011) noted that social network applications like Skype act as enablers of the SNVDS by allowing a line of communication and collaboration between the stakeholders. Skype is a free application that allows high-definition video and voice communication over the Internet. Through Skype student designers are able to share texts, images, drawings and photos of physical models in development.

These authors also established that Web 2.0 based applications such as Ning assisted not only as information repositories for students' research work on the project but also as a meeting place for them to discussion, exchange and explore their ideas (Ham & Schnabel, 2011). Web 2.0 technology gave student designers opportunities to interact and work outside studio hours. In the traditional space at the university they were limited to use of emails and telephone calls only in circumstances where special consideration was required, for example notification of absences, illnesses or other problems. Web 2.0 technologies were used to allow students to post their latest project work for their lecturers and external experts to assist them with relevant comments for their progress. This was done both on- and off-campus, thus further blurring the distinction between the virtual and the real. However, Ham and Schnabel (2011) also point out that some limitations might occur, depending on the use of an appropriate audio and video system as well as the available bandwidth.

In conclusion, I want to note that the literature indicated the potential of Web 2.0 technology to take the design environment and practice to the next level. With the proliferation of nomadic

digital technologies there is great potential for further engagement with Web 2.0 technology in the VDS. Coupled with the almost ubiquitous student access to the Internet and various forms of mobile computing devices, Web 2.0 technology has potential to facilitate a more engaging design learning environment that intersects various physical and virtual realms, as well as social and cultural elements of the design.

The Web 2.0-facilitated design studios (SNVDS) differ from the traditional models of design studios in that the students themselves became the primary contributor to skills, content and knowledge required for the design project. They also differ from the conventional notion of design as problem solving due to the different ways in which the problem is framed due to the mediation provided by the technology employed (Schnabel & Ham, 2012; Schnabel & Howe, 2009). The SNVDS not only helps to frame the problem differently (Kvan & Gao, 2004) but also engages designers through the collaborative design, that results in a collective intelligence that enables designers to come up with a wide diversity of design solutions.

2.3.5 Summary

In this final part of the literature review I looked at the meaning of Web 2.0 as given in the available literature as my starting point to argue for an ANT view of the concept. In explaining Web 2.0, definitions highlight collaboration as a major outcome. Web 2.0 is essentially described as a collaborative platform. Furthermore, some traces in definition show that Web 2.0 is user-centric and may easily be personalised, thereby translating computing into a social phenomenon. Thus Web 2.0 technology has been described as social and participatory technology. However, my argument from an ANT perspective is that such definitions are rather deterministic, since they point to the affordances that these technologies provide.

For a complete understanding of Web 2.0 technology I therefore, propose an ANT perspective as the lens one could use. From an ANT perspective I have argued for us to consider Web 2.0 technology as more than a set of tools. Without neglecting ANT's contention that there is no fixed object in the social network but only object formation, I have adopted the view that "Web 2.0 is a set of threads and tendencies, initiated by a set of principles and practices that are mobilized through a set of tools" (Depauw, 2008, p. 13). In short, Web 2.0 should be viewed as the multiplicity of applications and Web-based services that are increasing our embroilment with each other in professional activities such as collaborative design.

I have also demonstrated that there is a considerable amount of research that has focused on the role of Web 2.0 technology in supporting and enhancing design education. This research has illuminated the different ways in which Web 2.0 tools are used to facilitate collaborative design. Many of these studies have provided a descriptive account of the use of these tools from a technology deterministic approach, since their discussions tend to lean more towards the affordances which these technologies provide. The inadequacy of such research is exposed when they fail to articulate the intricate nature of associations that constitute collaborative design when facilitated by Web 2.0.

As Paulini et al. (2011) argue, developing successful collaborative design goes beyond understanding how technology supports individuals to include understanding how technology constitutes and structures the design task so that the designers are motivated to participate in the design project. However, this research is important to me because it has helped me to illuminate the inadequacies of both the technological and social deterministic approaches to studying the role of technology in collaborative design. Hence the studies have formed a good basis for my further research on the role of Web 2.0 technology in collaborative design from an ANT perspective. In the next chapter I describe the ANT methodological trajectory which I took to accomplish this study.

CHAPTER 3

METHODOLOGY:

MAPPING OF THE FOLLOWING ACTORS

*"Using a slogan from ANT, you have **'follow the actors themselves',** that is try to catch up with their often wild innovations in order to learn from them what the collective existence has become in their hands…"*
*—**Bruno Latour (2005, p.12)***

3.1 Introduction

In this chapter I map the research methodology for this study and demonstrate how I used ANT to guide the research design I employed in carrying out this study. In particular, I discuss how I deployed ANT concepts as methodological tools to explain how engineering students used Web 2.0 technologies to facilitate the collaborative design process. Drawing from suggestions made by Latour (2005, p. 133) that we keep track of all our moves "as everything is data", I explicate in detail how I made sure that all data were collected and kept. I also describe in detail how I followed both the conspicuous and inconspicuous actors' practices at all the three nodes I identified during the study. Latour (2005, p. 33) refers to threats to validity of research as the "objectfullness" of the data constituted, therefore, in this chapter, I give a rich explanation how I was able to ensure the objectfullness of the data. I also elucidate the data analysis plan from ANT's point of view. I close the chapter by giving a summary of the main points raised is my discussion of methodological approach to this study used.

3.2 Philosophical negotiation of the study

To avoid being labelled reductionist, that is trying to deduce or build explanations, I have called this section 'Philosophical negotiation' instead of the usual heading 'Philosophical foundation'. Every research methodology stems from a particular philosophical standing (Hounshell, 1984). Research methods are not simply neutral tools, "they are shaped by the ontological and epistemological beliefs which underpin them" (Bryman, 2004, p. 4). Hounshell (1984), warns that ignoring the philosophical standing of the research methodology compromises the validity of the research practice, which can lead to distorted findings. With

regard to the philosophical underpinnings of the study there are issues of ontology *(What constitutes reality and how can we understand existence?*) and epistemology *(What constitutes valid knowledge and how can we obtain it?).* These two aspects will direct how the researcher deploys the methodological tools of the study. Tuli (2012, p. 15), sums this up aptly:

> The selection of research methodology depends on the paradigm that guides the research activity, more specifically, beliefs about the nature of reality and humanity (ontology), the theory of knowledge that informs the research (epistemology), and how that knowledge may be gained (methodology).

In research ontological, epistemological, and methodological beliefs are packaged together into paradigms; a paradigm is defined as "a set of propositions that explain how the world is perceived" (Sarantakos, 2005, p. 30). So by choosing a particular methodology, the researcher indirectly chooses a particular way of viewing the world and commits him/herself to certain ways of knowing the world. Therefore when carrying out a study it is important to examine the underlying ideas, values, and assumptions that the proposed methodology brings to the study. Following this advice, I considered the rationale for using ANT as the methodological and analytical framework for this study from a philosophical point of view.

The methodology of this study is based on the ontological and epistemological perspectives of ANT, from which the theoretical framework for the study is drawn, as described in the previous chapter. With regard to research paradigm, ANT is widely valued for its apparently anti-essentialist or relativist ontology (Gibson, 1979). ANT sees reality as relative and co-constructed and something that exists within the network and in the translations, and therefore has been presented as a sociology of translation (Callon, 1986).

ANT's ontological stance presumes a world that is processual and enactive (Conole, 2013). It views the world as inherently dynamic, complex, and multiple, and built upon relations, based on connections among entities. As such, ANT does not agree with the philosophy of causality used in social sciences (Latour, 2005), but explains that the relations are indeed the reality. As Latour (2005, p. 103) points out: "every time some A is said to be related to some B, it's the social itself that is being generated". The reality is nothing but actors embedded in their relationships and events are taking place in each instant (Latour et al., 2011). In other words, reality is thus co-constructed through relations. Any change, whether big or small, modifies the way that actors interrelate to each other. Reality is constituted in the network, and if there is an "*out-thereness*" (Latour, 2005, p. 243), then it is an out there beyond the network, constituted

by other networks. Neither individual agents nor technologies such as Web 2.0 are considered real outside their enactment in practice.

ANT is therefore suitable for questioning reality since it has been reified by the social explanations (Latour, 2005). There is no such thing as an objective reality; facts are not 'just' out there waiting to be discovered – the focus on investigation should be on what is related/ unrelated, and as long as other actors relate to the actor, it is considered real (Akrich, 1993), and the distinction between subjective and objective becomes meaningless. Actors are absolutely concrete entities and without relationships are utterly cut off from existence. The reality of the actor is its way of perturbing, transforming and jostling other things (Latour et al., 2011).

ANT ontology allows for the study of not only the resulting construct, but also of the heterogeneous elements participating in the construction (Latour, 2003). ANT ontology allows the researcher to investigate how the actors make connections, and shape the network they create through the relations they make. As Latour (2005, pp. 131-132) defines it, "network is a concept, not a thing out there. It is a tool to help describe something not what is being described …. (It) is the trace left behind by some moving agent". Latour refers to ANT as a theory of association, whose activity it is to trace and assemble associations or networks.

In an ANT study associations are the fulcrum of the inquiry. The process of tracing networks associations is the central premise of ANT methodology. Alliances are what really matter, and allies work to make the networks and their relations stronger or weaker than the one already existing (Latour, 1987, 1988). Central to ANT is the definition of objects as always being in relation to the network in which they are embedded. According to Law (1999), this is the relational materiality that underpins ANT's ontology. ANT's ambition is to treat entities and materialities as enacted and relational effects and to explore the configuration and reconfiguration of those relations (Law, 2004, p. 157).

The most controversial and yet most known resource from ANT's ontological toolkit is the principle of generalised symmetry. According to this principle, humans and non-humans should be given equal analytical attention in the analysis of the unfolding of social actions. Indeed this principle seems to be an odd analytical standpoint, given the seeming differences between the intentional actions of humans and the material causality of objects (Pickering,

1993; Vandenberghe, 2002). However, it is arguably important in shedding light on ANT's two ways of approaching actors, that is, as intermediaries or as mediators. As I have established in Chapter 2, intermediaries are actors which simply transport meaning and force without transformation, while mediators transform and translate meaning during the process of transportation.

As a result of the generalised symmetry principle, there are no actors that are ontologically more important than others (Latour et al., 2011). All the actors, both human and non-human, are on the same wavelength in making their relations and their position in the network stronger. Thus, the role of non-humans has to be studied as well, because studying and taking them into account is what has been missing in many previous design studies (Latour, 2008). Furthermore, the principle of symmetry's extension of agency to non-humans is not limited to material objects, but also includes things that may not have a clear material existence, for example concepts and texts. Since ANT's focus is on actors and their relationships, the critical questions that researchers should be asking are not 'What is it?' but rather 'How is it happening?' and 'How does this emerge?'

In practice, the relations created between non-human actors are not metaphysically different from those between human actors or human and non-human actors. Therefore, it is important not to change the register in our description, since the human and non-human actors have to be treated and described in the same way (Callon, 1986). However, ANT does not have a prescribed vocabulary or a way of describing these associations and network constructions and maintenance, but each researcher has to choose his/her own way of describing them because it is not possible to delineate a universal method of description (Callon, 1986).

Since nothing is known but only realised, ANT rejects explanations that appeal to the essential characteristics of actors (Latour, 1988). For example, the collaborative design process should be explored as a processing that is emerging from networks of designers, their tools, artefacts, and the institutions in which they take place. The aim is to denaturalise this process by viewing it as continually made and remade as opposed to existing 'out there' with inherent properties and characteristics (Borgeman et al., 2008).

In terms of epistemology ANT is often positioned as an approach that embraces epistemological relativism (Mould, 2008) and is resolutely reflexive. There is no universal

truth, but the interpretations are constructed within a particular network. Therefore, studies involving ANT should seek to examine empirically how truth is produced rather than how it is discovered. ANT thus departs from the positivist assumption that research is a value-free way of uncovering reality. As a result, ANT is often considered to be a reflexive approach because it rejects the claims of objectivity that are typical of a positivist research paradigm. Instead, ANT seeks to tease out some ways of understanding held by actors on their own lived realities (Latour, 2005) by allowing them "to define the world in their own terms" (Law, 2007, p. 20), and seeking to "struggle against producing its own vision of the world" (Gibson, 1979, p. 398). However, the challenge that I had to grapple with in the methodology of this study was how to make the non-human actors 'talk', that is how to make them provide descriptions of themselves or to produce scripts of what they are asking others, humans and non-humans to do (Latour, 2005).

3.3 Research design

My adoption of ANT as the theoretical lens in this study suggests a paradigm shift in design research. The biggest challenge that needed to be overcome in collaborative design research is the subject/object separation that is evident in most design research approaches. This challenge is, however, dealt with well by ANT's ontological position that recognises that agency is distributed equally among human (subject) and non-human (object) actors. The focus of the research methods was to understand the dynamics in the assemblage of the collaborative design actor networks that are facilitated by Web 2.0 technologies. The basic technical arrangements of such a process, including the enrolment of non-human actors such as inscriptions and design collaboration tools (Web 2.0 technologies) which are normally taken for granted, are brought to the fore using ANT. Since these non-human actors are usually taken for granted, the material arrangements and the discourses they sustain are overlooked in many studies that try to understand socio-technical practices such as collaborative design carried out with the aid of online tools like Web 2.0 technologies. The aim of the research was therefore to draw such taken for granted aspects of collaborative design into visibility and thoroughly explore how they function, and to examine their effects on other actors as equal participants in a collaborative design network.

ANT offered me resources that helped me to deal with the methodology challenges I alluded to above. As regards research design, ANT is based on the ethnographic approach of collecting data that involves following actors, interacting with the observed, inquiring and producing

descriptions (Bogic, 2010). Through its reach vocabulary the ANT framework provided me with resources that I used to describe how networks emerge and interactions took shape among the actors during the collaborative design process. ANT is not a static description of nodes and hubs but a process methodology which seeks to describe the action around each node. Sosa and Gero (2003), some of the proponents of ANT, suggest that phenomena have to be studied in action, focusing on the dynamics rather than the stability of the relationships. The actors are not defined and analysed in a stable set of relationships (Joel, 2011) but rather in a dynamic and meta-textual context of Web 2.0 Internet-based technology. As Latour (2007a), has observed, the Internet provides unprecedented possibilities when it comes to the traceability of social interaction. Marres (2004, p. 134) , also notes that even "the most ephemeral social phenomena, like conversation and the circulation of rumours, are documented and archived". Using the Internet as a resource also extends the idea of following the actors in ethnographic studies: what Hine (2006) has termed "mobile ethnography". Mobile ethnography is aimed at looking at connections rather than locations or nodes. As Hine (2006, p. 64) puts it "The object of ethnographic enquiry can usefully be reshaped by concentrating on flow and connectivity rather than location and boundary as the organizing principle". In this section I illustrate how I deployed the ANT methodological principle of following the actors through the trajectory of the collaborative design network.

This selection of the design was influenced by ANT as my methodological framework, which sought to use qualitative descriptions of students' experiences for me to construct a broad picture of how student designers made use of Web 2.0 technologies during the collaborative design processes. The research design is organised to focus on the issues of gaining access pertaining to each node, a discussion of the traits to be followed, how data are constituted and steps taken during analysis of data.

Figure 7 illustrates how the methodological issues I have discussed in section 3.2 and 3.4 are linked. In the next section I explain how I mobilise an ANT methodological strategy to collect the relevant data for this study.

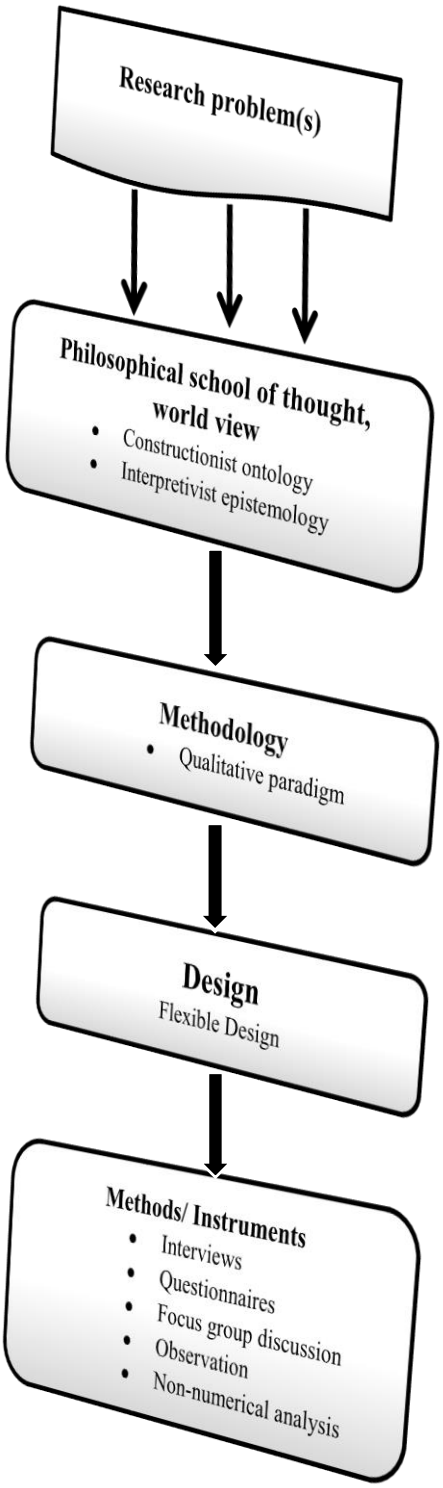

Figure 7: An overview of the research methodology.

3.4 Mobilising an ANT methodology for tracing the collaborative design network

With regard to research methodology ANT has several guidelines, but the most useful for this study is *following the actors* through the moments of translation processes, from problematisation through interessement, and enrolment until the mobilisation moment. As Latour (2005) points out, an ANT report is a description of the translation as well as the transformations that results from the set of relations defined by the translation. It is through these descriptions that "the social is performed" (Latour, 2005). The task of the research is then to keep track of all the moves, including those involving the writing of this report, because Latour (2005, p. 133), argues that "everything is data, even those that deal with the production of the report", not for epistemic reasons, but is because everything is considered to be relevant data in assembling and reassembling of the social.

Using ANT's flat ontology the methodological focus of this study was to follow and observe the actors to see how they related and the associations they made during the Web 2.0- facilitated collaborative design process, and how these were understood and made sense of by actors themselves. Approaching research from this perspective meant that the nature of reality was understood to be a product of associations among the actors involved. According to ANT reality is constructed through the ties made among the actors. Therefore the collaborative design process can be understood by examining practice, that is, what actors do and what meanings the actors ascribe to their actions. From ANT's perspective this practice is constructed in an ongoing relational process that is mediated by artefacts and always rooted in a context of interaction (Latour, 1992). Looking at how activities such as collaborative design are executed reveals not only the decisions of the designers but also the work of other actors in the design process (Bogic, 2010).

For the purposes of record-keeping, Singh-Pillay (2010), suggests that four notebooks be maintained by the researcher:

- a log of the enquiry in terms of due dates, time frames, appointments, etc.;
- recording of data findings;
- recording of data analysis while still doing field work; and
- mapping the social from the network traced.

Taking the advice from Singh-Pillay (2010), I maintained electronic files of these records, which I kept in clearly labelled folders as described below. I opened a folder entitled '*Important Dates'*, where I kept dates for the PhD cohort seminar, due dates in respect of ethical clearance and data collection at the nodes, dates for site visits, dates for time frames of the study and other related information. The second folder was labelled *'Correspondences'*, where I keep all emails sent and received in respect of the study from my co-supervisors and cohort coordinators, from the authorities at the research site and other relevant emails. The third folder was labelled *'Following the Actors'*, where I kept all the data collected during the tracing of the trails left by the actors. The fourth folder was labelled '*Network Assemblage'*, where I kept a record of the analysis done during field work and after the field work when the social was finally mapped. The schematic representation shown in figure 8 illustrates what the files I maintained looked like. These files were closed upon completion of the study.

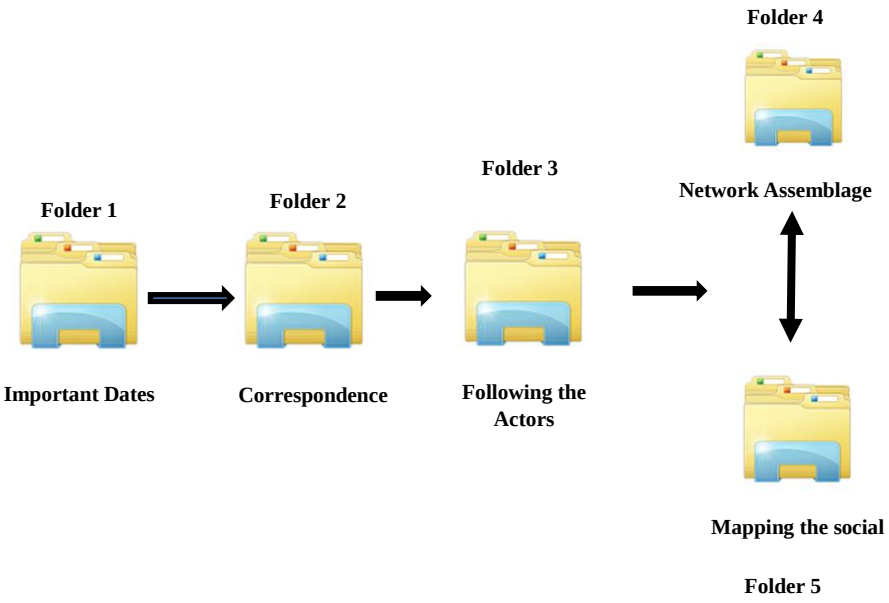

Figure 8: Schematic representation of the folds opened.

In order to map the social I needed to trail the practices engaged at each node, which are brought to the fore in the section below.

3.5 Practice(s) to be trailed at each node

The design studio is the main node at which most of the design activities are carried out. However, with the advent of Web 2.0 technology in collaborative design two other nodes came into view: the university's LAN and the Web 2.0 design working space. These nodes emerged as I was following the actors as they went about the design process. The student designers

moved up and down between these places as they worked together to provide a satisfying solution to the design problem. Since the design process was constituted around these nodes, my methodological approach draws on ANT's concept of a network to constitute data at each identified node. As mentioned previously (in Part A of Chapter 2), networks are construed as consisting of actors that are connected together by associations. ANT research is preoccupied with discovering how that enactment takes place and critically looking at "what the links are in the chain and how they are maintained, oiled and soiled, activated and destabilized" (Conole, 2013).

3.5.1 Design studio node

The design studio is the traditional place for teaching of design. This is the place where design ideas are conceived and debated. For the design project carried out during this study, the student designers received the design brief, stipulating the design problem from their lecturers. As soon as student designers receive the design brief and the relevant instructions, the group formation process is started, but does not end there. Group formation continues on the other two nodes as student designers continue their interaction. Different interpretations of the design problem are presented and discussed. One student emerges as the group leader (the focal actor/ spokesperson in ANT terms) to provide leadership and guidance to the group. It is at this node where the agreed solution is translated into working drawing. In ANT terms working drawing can be viewed as inscriptions which prescribe how the agreed solution can be realized in the Engineering workshop. Therefore, working drawings can be considered as intermediaries, since they only convey information on how the design solution has to be created. We also note that the design studio is the place where the design translation starts and gets finished when students *black-box* their agreed solution to the problem into working drawings.

3.5.2 University local area node

The university has fibre-optic Internet connectivity with a bandwidth size of over 300Mbs speed. This Internet connectivity is made available through campus-wide Wi-Fi that is available to all students at the university. Students were free to connect to the Internet through their laptops and other mobile computing devices such as tablet computers and smart phones. Students also had the option of using computers in the computer laboratories at the university.

At this node the focus was on which Web 2.0 technologies students were enrolling to their design networks. What computing and networking hardware and software were enrolled into their design work, what associations were created, and how were these translated to other actors? For example, what happens when Internet connectivity is lost?

3.5.3 Web 2.0 node

At the Web 2.0 node participants were followed through the postings they exchanged during the design process. The focus was on tracing how the collaborative design groups were formed at the early stages of the design process. The questions that needed to be answered were what happens at the beginning of the collaborative design venture from the moment a new idea is generated, and how is the decision taken to start a project based on this new initiative? Also, how are new design ideas developed and progressively accepted by the group? It should be borne in mind that these questions are complex because the early stages of design are not well-defined phases of the design activity, made more complex by the negotiation between different participants in collaborative design.

3.6 Mapping the objectfullness of data constituted

Like other qualitative studies, ANT studies are also concerned with issues of validity. Latour (2005, p. 33) refers to threats to validity of research as "objectfullness" of the data constituted. From an ANT perspective, data constitution allows for socio-material elements to be trailed by the researcher. Latour (2005, p. 33) suggests that, in an ANT study the role played by the researcher is very critical in ensuring the "objectfullness" of the data collected; the researcher's major role is "to follow the actors", assemble the trails they created and to be "one reflexive loop behind the actors". On the same issue Singh-Pillay (2010, p. 70) suggests that when "following the actors and picking up the trails left by an actor, the enquirer is obliged to record everything without being selective about which trails to pick up". However, the challenge in tracing associations using ANT is how the researcher can let the actors do the acting themselves; that is, letting them ''re-associate and reassemble the social'' (Latour, 2005, p. 5). Singh-Pillay (2010, p. 70), further suggests that:

> The enquirer therefore does not impose order by limiting the range of 'acceptable accounts' provided by the actors. All accounts provided by the actors are assembled.

No actor is placed a priori, in a context or by defining their identities with any predetermined framework. ANT requires that we follow the actors as they create context and their identity themselves. As a result of this, the ANT researcher is freed from the subjective selection and tracing of data.

Therefore in the data gathering stage I took due care to allow the actors themselves to define and assemble what constituted my data. I followed all the actors which exerted their agents noting down every action they took and effected, as the collaborative design was enacted and constituted. In the next sections I elucidate how I mobilised an ANT research design to collect the traces that constituted data for analysis and assembling the Web 2.0-facilitated collaborative design.

3.7 Gaining of access

Gaining access to the nodes of the study meant dealing with various gatekeepers, for example the university registrar, the chairperson of the Department of Industrial and Manufacturing Engineering (IME) and the Information Technology Services (ITS) director at the University. According to Von-Glasersfeld (1995, p. 52), a gatekeeper is "someone with formal and informal authority to control access to a site". After obtaining the ethical clearance from the University of KwaZulu-Natal, I applied for formal permission to carry out my study at the Harare Institute of Technology, which was granted on 20 August 2013 on condition that the study would not interfere with the smooth running of the day-to-day activities of the department concerned. I used this letter to gain access to the students through the Chairperson of the Department of IME, who introduced me to the lecturers who were working with the students that participated in the study. The students who agreed to participate were given consent forms to complete to show their voluntary willingness to participate. I then sought both formal and informal permission to gain access to the students' online Web 2.0 discussion by subscribing to their groups as a guest or non-participant observer. After failing to get access to the university server for security reasons, the ITS director instead agreed to make the activity log for the students on the university LAN available to me as print-out.

3.8 Data collection procedure

ANT's methodological principle has no unique set of methods which it is associated with, but makes use of the same techniques as ethnography and case studies. So for this study, I used data collection instruments which are commonly used in ethnographic studies, namely;

questionnaire comprising of closed and open ended questions, semi-structured interview schedule, observation schedules, and non-participant observation of online actives by the student designers. This mixture of data collection instruments was necessary because the task of following actors in a complex and dynamic network line Web 2.0-facilitated collaborative required me to be well equipped. I needed to trace the emergence of the web 2.0- facilitated collaborative design paying attention on the ever changing associations that kept or destroyed the emerging network. My focus was on how the design process was constituted through the associations formed among the actors.

After gaining access to the research site and the particular nodes, my next step was to map out how data were going to be gathered. My expectation was that the relevant research data would emerge from the associations that were formed among the actors in the collaborative design process. This is consistent with ANT which call for researchers to study networks from the actors' point of view, that is, by simply following the actors (Latour, 2005). As such the underlying principle of my data collection was to "follow the actors" (Latour 2005). This involved tracing the network and its shifting ties which occur at the three nodes with respect to both the human (students) and non-human (the technologies used) actors without privileging one over the other. Data collection was a continuous process as the actors proceeded with their project.

The ANT dictum to "follow the actors" opens up the research field to an endlessness list of actors which could be followed. However, since my aim was to explore how student designers used Web 2.0 technology during the collaborative design process, I employed a maximum variation sampling strategy. This sampling strategy of purposeful sampling can help the researcher to illuminate significant common patterns across the variation (Patton, 1990). Firstly, I created a list of potential human and nonhuman actors in the process. I followed the actors as they traversed the three nodes of the Web 2.0-faciltated collaborative design collecting traces of how they linked among themselves.

The notion of collaborative design being interactive and discursive (Schön, 1983) suggests that listening to actors' voices is essential to this research. To map associations and assemblages that students formed during the collaborative design process, I followed actors by episodic interviews like an ethnographer (Van-Maanen, 2001). Episodic interviews are "based on the theoretical assumption that narratives are constituted experience rather experiences per-se"

(Tabak, 2015, p. 62). Episodic interviews are relevant to ANT studies because they seek for knowledge which is linked to action and situational context such as time, space, person, event and situations. Flick (1997), highlights three important things that make episodic interviews to succeed:

1. The interviewer should combine questions that allow the actors to recount specific events and more general questions on the subject being investigated.
2. Questions should address specific situation of the actors' experiences
3. The interview should be open enough to allow actors choose episodes that they found to be most interesting and relevant to them.

The table 1, below shows a summary of the data collection plan.

Table 1 Data collection plan

Node	**How actors were followed**	**The actors followed**
University LAN	Questionnaire Semi-structured Interviews Activity logs	Design briefs Students Web 2.0 technologies
Design studio	Activity logs Screen capture Archives	Students Web 2.0 technologies Design inscriptions
Web 2.0 discussion spaces	Discussion forum archives Inscription observation schedule	Students Web 2.0 technologies Design inscriptions

Drawing from Flick's (1997) steps of interweaving, I devised the following strategy which I used to collect the relevant data from the actors:

1. Prepare for the interviews ensuring that I had all I needed to record and document the interviews and getting them to sign the consent forms.
2. Introduced my own view of the subject of my research to the participants
3. Obtaining the views participants' conception of the subject of my interview and their biography in relation to the subject.
4. Establish the participants' interpretation of the subject of my study.
5. Ensuring focus on the key issues of my study.
6. Asking some general issues related to the subject of my study.

7. Evaluating and conducting small talks.
8. Documenting the interviews.

I requested eight students, who assumed the position of the group spokespersons, to participate in the interviews. All the interviews were made in person and recorded using a digital voice recorder with participants' permission. Each participant completed a consent form to indicate their willingness to enter the study. However, to complement the recorded interviews I also took some notes. The duration of each interview ranged from 20 to approximately 40 minutes, depending on how many follow-up questions we asked. As noted in the section above, the questions used within the interview script were largely influenced by the stages of translation of ANT. I used the stories I generated from these interviews to trace the actions of the actors in the Web 2.0-facilitated collaborative design process as well as mapping the associations they described.

In order to collect data from the online discussion I asked permission from students to join their discussion as a guest. This meant that I was not going to interfere with the discussions of the students; however, I was able to collect all the discussions as they took place online. My task was to record the data and refrain from influencing what participants shared, thus giving the data the opportunity to tell the story. The actors led the direction of the research, which includes both human and non-human actors, to describe the design network since the task of my strategy was just to follow the actors.

It is noted that digital data collection spaces such as social networks, wikis, blog postings, and online forum discussions are often in a state of continuous flux, revision, and transformation (Adams & Thompson, 2014). Data collection from these places raises questions about what exactly constitutes data, or in Latour's (2005) words, what is happening downstream. ANT's answer is that everything that takes place is data. My data collection involved engaging various strategies and software to freeze and capture discussion postings into pdfs and sometimes taking screen captures, copying and pasting text or images into a word processing program. Most of these methods involved 'freezing' particular moments of the online life-world. Kallanikos, Aaltonen, and Marton (2010), give some words of caution that the snapshots produced by these methods are pages that have been temporarily assembled and presented in a particular space and time, and thus are no longer dynamic sets of information but have been rendered static with their links to the original source disconnected. Such digital artefacts are no longer mobile but frozen, decontextualised 'photos' (Kallanikos et al., 2010). Nevertheless,

these freezing practices enabled me to cope with the volume of information that was continually propagated by the Web 2.0 tools. In other words, in ANT terms, through these frequent acts of freezing digital objects, I was together with the technology tools engaged in the translation of digital artefacts and data, excluding and including some along the way.

Furthermore, these data captures were also enacting what Law (2009b) refers to as a barely noticed collateral reality and boundary making. Kallanikos et al. (2010, p. 7), suggest that these practices of archiving data do not simply collect already bounded entities but rather "construct the boundaries that demarcate and make an archival document". Once generated, captured and saved, these digital data become available for further translations and mobilisations through data analysis.

In an effort to bring Web 2.0 technologies to the level of actors in the collaborative design actor network, I treated them as key research participants in this study. Just as I collected data from students, I also collected data from various Web 2.0 technologies, which included Facebook, Twitter, WhatsApp, and LinkedIn as research participants in their own right. At first sight this idea seemed to be a bit off, but after a closer look it appeared less inexplicable. It is common knowledge that in the context of organisations such as universities the organisational sub-units, like faculties, departments, workshops, design studios and computer laboratories, can indeed assume some form of a life of their own. The same can be said about Web 2.0 technologies in a learning institution or when they are used in a learning context like a collaborative design project – they assume a life of their own and cease to be mere passive products. Since ANT considers the non-human elements of a network as equal participants with the human actors, the Web 2.0 technologies used by the participants constituted actors which needed to be followed, collecting the traces they left through the entire collaborative design process.

However, following the digital actors was not easy. To accomplish this I employed a variety of heuristics or 'tricks' to make the digital materialities of the network objects talk, "that is, to offer descriptions of themselves, to produce scripts of what they are making others-humans or non-humans, do" (Latour, 2005, p. 79). To collect data from Web 2.0 I made use of Adams and Thompson (2011), heuristics for interviewing non-human or "thingly" research participants. Digital actors in all their forms, including software, devices, networks, and artefacts, by their nature are notoriously fickle. Internet-based technologies in particular always exist as a flowing, indissoluble weaving of human-technology actors. They are often described

as unbounded, evasive, distributed, and constantly mutating (Kallanikos et al., 2010). For example, the Web appears to us as a process, happening continuously and continuously transforming before our eyes, with us and through us. However, although the websites that are built bloom and disappear, the Web continues, because the Web is made up of people and the digital technologies of the Internet (Thompson, 2014). Thus, Ruppert, Law, and Savage (2013, p. 24) observe that "digital devices and the data they generate are both the material of social lives and form part of many of the apparatuses for knowing those lives". However, in order to make sure that I did not lose any data, backing up on external storage was a daily practice.

3.9 Mapping how data are constituted

Drawing from ANT's methodological resources, I was able to come up with a scheme of data constitution at all the nodes that were identified as critical to the collaborative design process. The most important tenet of ANT for this research is its focus on performances, which includes associations or connections that are made between the actors with a view to account for the ostensive aspects of the set of associations produced (Feldman & Pentland, 2008).

Therefore data were constituted by tracing the trails created by both the conspicuous actors (Singh-Pillay, 2010) as well as some hidden or inconspicuous actors who appear and disappear during the translation process at the various nodes and all the stages of the collaborative design translation. Following these actors entails unveiling their action (Latour, 2005). The act of unveiling suggests looking for and unearthing hidden, an obscured background in relation to all entities constituting the network (Latour, 2005). At each node my focus was to scrutinise all the actions performed by the actors, that is what they said and did during their participation in the collaborative design process, in order to see what or who got enrolled or networked into the design network by the controlling actors of the networks I was observing (Latour, 2005). In real terms I found that I was not following the actors per se but rather was tracing circulating associations among the actors. Tracing networks by following the actors was critical for me because it would illuminate how socio-material elements take part in the collaborative design process, and what got performed through their participation (Daudelin, 1996). In this research the tracing of the emerging collaborative design network helped to bring to the fore the hidden presence of the social and technical aggregates involved in the collaborative design process.

Data for this research are constituted by tracing the trails that were left by the actors that were involved in the collaborative design process. At all three identified nodes there was some form of design translation which needed to be traced through the four stages of translation as suggested by Callon (1986c). Following the actors unveiled the actors' action (Latour, 2005). Data at each node were constituted at the various stages of the design process, from the problem analysis through possible solutions, evaluation of the chosen solution, production of the prototype and its testing.

3.9.1 Design studio

Data at this node were constituted by what happened at the beginning of the design project, tracing how the controlling or focal actor problematised the design problem, how other actors were attracted to the project through interessement and got enrolled into the project, how their roles were defined, and their acceptance of these roles through passing through the OPP. This was not an easy task given the fact that the early stage of the design process is complex and the designers attend to a myriad of design uncertainties and controversies that need to be resolved before a satisfying design solution can be agreed upon. In other words, the moments of the design translations are not well-defined phases of the design activity.

Various data collection instruments were used, including a questionnaire, an observation schedule and a semi-structured interview guide. I used the questionnaire to gather data related to the formation of the teams, namely the activities that the actors engaged in throughout the stages of the design process, from the time they formed their design teams to the time they presented their design artefacts to the departmental panel of examiners. In the process the key actors were identified. In addition, the questionnaire allowed me to illuminate the associations formed between the actors, including the non-human actors. The questionnaire also allowed me to collect data on students' experiences with Web 2.0 during their design collaboration. By collecting data on students' experiences, I was able to trace the association of actors with others actors in the collaborative design project. I could also collect data on students' interpretations of the effectiveness of Web 2.0 technologies in facilitating design collaboration. At the end of each section I left a blank space which students used to elaborate on issues they found needed further clarification or were not covered by the questionnaire, thus allowing actors to speak for themselves.

The interviews explored a number of issues, including students' backgrounds, their roles in during the collaborative design project, their experiences with Web 2.0 technologies, demographics, their opinions, feelings, and knowledge on the role played by Web 2.0 during the collaborative project. Since the questions were open-ended the interview schedule did not constrain the interview process; instead they allowed the interviewee to lead the conversation describing their associations.

The semi-structured interview guide allowed actors to tell their stories at liberty and gave me the flexibility to follow up on issues and probe actors to elaborate further if required. Many of the interviewees opened up by sharing personal experiences and opinions regarding the use of Web 2.0 tools to facilitate the collaborative design process, and were happy to elaborate and collaborate on any additional points I raised. More often than not, interviewees directed me to other actors or websites which confirmed their points of discussion. This facilitated the collection of in-depth students' views of their experiences in collaborative design that was facilitated by Web 2.0 technology. I successfully recorded and transcribed all of the interviews for analysis.

3.9.2 University LAN

At this node a questionnaire and the activity log were used to collect data on the Web 2.0 technologies that students were using, and the activity log was used to trace the relations, associations or ties that were formed in the process. It is also important to note that the university internet connectivity was also available through Wi-Fi which stretched beyond the university's physical boundaries.

3.9.3 Web 2.0 design spaces

At this node data were constituted following the actors through the traces left (postings) on the discussion forums. I was a non-participant observer/guest on the platforms, observing how students were interacting through the various Social Networking (SN) platforms they used which included, Facebook, WhatsApp, Twitter and MySpace . These were used to trace the association/ties which were formed as the actors went through the stages of the design process.

The table 2 on the next page summaries how data were constituted.

Table 2: Summary of how data were constituted

Node	Practice followed	Conspicuous actors followed	Instruments used to collect data
Design Studio	The design process	Students, design collaboration tool, Web 2.0 tools	Questionnaire, semi-structured interviews
Web 2.0 discussion places	Group formation Early stages of the design process	Students, design collaboration tool, Web 2.0 tools	Questionnaire, online observation of Web 2.0 postings, post-observation
University LAN (Wi-Fi)	Group formation The design process	Students, design collaboration tool, Web 2.0 tools	Questionnaire, activity log, observation schedule

3.10 Mapping the design for analysis

The ANT analytical framework guided data analysis for this study. The ontological position of ANT that views practice as an assemblage of the heterogonous entities in a network location (Latour, 2005) was found to be crucial in interpreting the meaning of data in this study. The aim of the analysis was to understand the following for the collaborative design:

1. Who are the actors in the networks?
2. What translations, mobilisation, enrolment and spokespersons can be identified?
3. What is the role of the actors in the collaborative design process?

The overall aim was to understand the role played by Web 2.0 in collaborative design and the implications (the role of Web 2.0 technologies in the process, technologies mobilised to constitute collaborative design), as well as implications for theory and practice. The focus of ANT's analysis in this study was to examine the translation process (Callon, 1986c) in the collaborative design network, where actors would align their interests with the controlling actor of the actor network (Tilson & Lyytinen, 2005).

The main objective of the data analysis was to capture and understand the actors in the collaborative design network as well as the actions taken to tell the whole story (Latour, 2005). This entails interpreting actors' behaviour and how their roles were exposed and translated during their interaction in the collaborative design using Web 2.0 technologies. Since from ANT's perspective practice is construed as an assemblage of socio-material actors in a network (Latour, 2005), analysis of the data therefore involved an assemblage of the trails traced. As explained in Chapter 1, the focus of the study was on the process of assembling heterogeneous actor networks rather than delineating and describing distinct entities.

The analytical framework is re-elaborated by Latour (1994a, p. 46):

> In abandoning dualism, our intent is not to abandon the very distinct features of the various parts within the collective. What the new paradigm attends to are the moves by which any given collective extends its social fabric to other entities. First, there is translation, the means by which we inscribe in a different matter features of our social order; next, the crossover, which consists in the exchange of properties among nonhumans; third, the enrolment, by which a nonhuman is seduced, manipulated, or induced into the collective; fourth, the mobilisation of nonhumans inside the collective, which adds fresh unexpected resources, resulting in strange new hybrids; and, internally, displacement, the direction the collective takes once its shape, extent, and composition have been altered.

The analytical framework is therefore constituted by the following elements:

- Actors (actants/allies): These are defined by their relations; they are "network effects" (Law 1999, p.5), and form the network in which the design is mobilised and the collaborative design process takes place. Networks become actors through the continuous work of stabilisation.
- Spokesperson: The person who is mobilising goals; speaking on behalf of the design; stating a programme of action.
- Translation: The drift; the link between actors; what makes an actor what it is; how it emerges; and how it comes into existence.
- Enrolment: The processes and arguments that made the actors part of the network and support the design.
- Mobilisation: A series of actions that start with an interest and is generally considered to be consequential then translates the actors to adhere to the programme of action.

Actors (also referred to as actants or allies – both humans and non-humans) are associating because they are translating the aims and goals in something they recognise and accept. Actors

have the same ontological dignity; there is perfect symmetry between humans and non-humans, and they can be elaborated on (unravelled) as themselves as comprising a network, or they can be black-boxed. Actors become stronger to the extent that they can firmly associate with other enrolled elements (Callon & Latour, 1981b).

There are two categories of actors, namely intermediaries and mediators. Intermediaries are actors that give form and consistency to the heterogeneous relations in the network. They have well-established input and output, such that if their input is defined it is enough to understand the output. Mediators, instead, convey information in the network and their input is not a good predictor of their output; as a result they need to be analysed in detail through their associations. Mediators transform and translate the meaning they are supposed to carry, originating new translation, making the movement of and in the social visible to the researcher (Latour, 2005). The main difference between an intermediary and mediator is not whether they have an identity, but rather if they act and thus have agency (Czarniawska & Mouritsen, 2009). During network formation allies (actors) make decisions, and these decisions contribute to setting up other allies or making them adversaries or sceptics (Akrich et al., 2002).

A spokesperson is an actor who is able to translate, speak, or act on behalf of other forces or actors, because he has persuaded the other actors after a chain of negotiations, intrigues, and calculations (Akrich et al., 2002). He/she is a translator representing the entities he/she constitutes (Callon, 1986c). A spokesperson becomes stronger when he/she can talk for and represent the actors mobilised and enrolled in his/her programme of action, but becomes weak if he/she has problems in the translations. Translation becomes disloyalty when an enrolled entity refuses to enter the actor world in order to expand into others. The destiny of most spokesmen is usually being viciously contradicted because entities are not easily translated (Callon, 1986c).

There are two types of spokespersons, objective and subjective. An objective spokesperson is the passage point and his/her ties persist despite the efforts of detractors. Thus, an objective spokesperson can speak on behalf of other actors, while a subjective spokesperson cannot speak in the name of other people but represents only him/herself (Akrich et al., 2002). An objective spokesperson is successful and speaks on behalf of others because he/she is entitled to make actions and decisions that will be crucial for the design process (Akrich et al., 2002).

Translation builds an actor world from entities. It involves the definition of roles, and the delineation of a scenario. It attaches characteristics to actors and establishes more or less stable relationships between them. If a translation is successful, it leads to the mobilisation and enrolment of actors. However, a translation may be resisted (some elements may not be easily enrolled into a network of relation), so translation is a product (result or effect) as well as a process.

Mobilisation characterises the ordering of the various network elements, which gives the network its strength and durability. When actors are mobilised, it is not all network elements which are 'active', but they all contribute to the network's durability because of the mutual relations they enter into (are 'fixed' into) through their mutual simplification and juxtaposition (Latour, 1987b). Enrolment is the process of getting the control of actors to participate in the construction of facts and to make their actions predictable (Latour, 1987b). If these processes are successfully accomplished, then the network is stabilised and there is support for the actors in the process. Because these concepts are connected, in the analysis they are described in the same paragraph (translations, mobilisations, enrolment).

Furthermore, ANT's notion of the network enabled me to illuminate the associations formed among the actors. It was essential for me to examine and illuminate the associations established within the collaborative design network as these were critical in the shaping and reshaping of the collaborative design process. In a collaborative design actor network, these associations or ties are bound to affect actors as they translate their practice through the complex web of interconnections that they make. I traced associations to reveal the alliances, convergences and sometimes divergences or subversions encountered during the collaborative design process. My illumination of the associations formed focused on the ways in which the network of relations was composed, how they emerged and how they were maintained, as well as how they were made durable over time (Latour, 2005). During the analysis I took due care to avoid privileging a particular type of constellation, giving particular attention to the thickest linkages made by the different actors in the mounting collection of data. This means that individual actors or humans did not necessarily stand in the centre of the analysis; sometimes inscriptions, important types of relations and technology did took centre stage.

I took due care to ensure that the data analysis upheld the three major methodological tenets of ANT: (1) the principle of agnosticism, which emphasises the impartiality of the researcher

towards the human and non-human actors, (2) the principle of generalised symmetry, which concerns the researcher's commitment to treating both human and non-human actors equally, and (3) the principle of free association, which avoids separation between humans and non-humans during the analysis (Callon, 1986c).

My scheme of analysis of data involved the following steps:

- Identify as many (human and non-human) actors as possible, considering the fact that humans and technologies can be considered as actors **(Research Question 1).**
- Investigating networks of associations and interactions through the moments of translation **(Research Question 2).**
- Building up a general picture of the relationship between the various actors and how their interactions and relations/associations created and facilitated the collaborative design process **(Research Question 1).**

In a nutshell, I analysed the data to provide answers to the research questions, which sought to identify the major actors in the design network, and identify the roles these played in the assemblage of the design networks through the associations they created during the design process. My data analysis was two-pronged, involving assemblage of traced networks at a nodal level and (re)assemblage at a cross-nodal level. Below I elucidate how I followed this scheme to assemble and reassemble the collaborative design network that was enacted by the actors involved in the process.

The long journey to interpret data collected through interviews started off with transcription of the data to create some order, to enable an initial understanding or overview of the collected material. At this preliminary stage I made a decision as to what was relevant from how I understood the data. This was followed by a distillation process where I distilled the data I found to be relevant and discarded that which I did not find to be of any use. I did this to get a better overview of the collected data. The next and final stage of my analysis was the process of generating key themes.

To understand the data I turned to some of the central concepts of ANT to provide tools for coding and categorisation of data in the analysis. Therefore the codes and categories did not emerge from the data. My interest was to go through the data with an eye for relations, practices

and translations that took place among the actors during the assemblage of the collaborative design network. I was also interested (as reflected in my first research question) in exploring the potential of the concept of 'actor' to include entities other than humans, hence the use of an all-embracing 'actant'. In order to fully understand collaborative design as an actor network (see Chapter 2, Part B), a focus on controversies was an important point of entry to understanding how actors constructed solutions to the design problem they were working on. I did this to shed more light on the third research question of this study.

This analytical framework is summarised in Table 3 below.

Table 3: Summary of the analytical framework

Translation moments	**Design stage**	**Analytical points/codes**
Problematisation	Problem definition	• Primary actor • What is the problem? • Problem solution • OPP • Relevant actor
Interessement (convincing Actors and getting actors committed)	Conceptual design Preliminary design	• Who to convince • How to convince • How to isolate competing solutions
Enrolment (actors accept to be part of the network)	Detailed design	• Agreement on the exact role of the actor • Benefits that actors will afford
Mobilisation of allies (actors become spokesperson; legitimacy of actors; network stabilised)	Design communication	• Actor(s) become spokesperson(s) • The network is stabilised or not stabilised

Since the focus of this study was on assemblage of design networks, the process of coming up with themes was, as I stated above, guided by ANT's moments of translation, which include the following phases:

- Actors
- Spokesperson
- Translation

- Problematisation
- Enrolment
- Interessement
- Mobilisation.

Using the descriptors of these moments of translation, I was able to create codes that I used to identify themes around each of the four moments of the translation. I developed these codes from key words that the actors used across all data sources to trace and identify similarities, recurring patterns, and differences in what the actors said or did in the associations they formed with other actors at each stage of the design process, as expected in the module outline. I used these key words (codes) that the actors used to serve as descriptors for the moments of translation they experienced in the associations they formed at each stage of the design process.

The first thing the analysis had to do was to identify the problematisation stage of the translation moment through which the collaborative design network was brought into being and its OPP. This was done through tracing the conspicuous actors of each of the design teams in terms of what they said and did which brought about or destroyed the actor network. By tracing what all the actor said or did I was able to identify and note all the actors including some inconspicuous actors that were networked and recruited into their practice (Latour, 2005). As mentioned earlier, the analysis revealed some inconspicuous actors which acted behind the scenes. These are the missing masses in most design researches, to use Latour (1992)'s term. This fulfils the first of Latour's requirements for understanding the network, namely identifying the actors within the network. In order to see how actors were interested into the collaborative design network, the analysis had to watch for information that could be used to understand how actors were enrolled and translated into the collaborative design actor network as it got to and subsequently traversed its OPP and moved toward stabilisation.

Secondly, the data collected at each node were analysed to identify and illuminate the role of each identified actor in the formation of the design network, and in so doing the second research question was answered. This was done to understand the actors within the network through identifying the traces they made/what they do/roles they play in a network. This entails identifying the activities of the actor network that are necessary for it to traverse its OPP. At the same time I needed to identify the spokespersons for each team and the action they performed to enrol other actors, and how they continued to sustain interessement, enrolment and mobilisation as the network moves toward stability or instability. Inscriptions are critical

to the stabilisation and black-boxing of the network's ideas. In designing, inscriptions include the sketches, working drawings and artefacts created during the design process.

Table 4, summarises some of the analytical questions I used to tease out meaning from the data collected.

Table 4: Summary of the analytical questions

Moment of translation	**Design activity**	**Analytical questions asked**
Problematisation	**Problem definition** • Revised problem statement • Refined objectives • Constraints • User requirements • Functions **Conceptual design** • Model and analyse conceptual design • Test and evaluate conceptual design	1. What is the problem that needs to be solved? 2. Who are the relevant actors? 3. Who are the focal actor(s) that are representing the group of actors? 4. How does the focal actor(s) try to establish itself as an obligatory passage point (OPP) between the other actors and the network?
Interessement	**Development of possible solutions** • Clarify design objectives • Establish user requirements • Identify constraints • Establish functions Definition of working criteria/goals Research and data gathering	1. How does the focal actor(s) get other actors interested? 2. How are the actors negotiating the terms of their involvement? 3. How are the roles of other actors defined? 4. How does the focal actor(s) work to convince other actors to take up their defined roles?
Enrolment	**Detailed design** • Design solution specifications • Manufacturing specifications Testing and evaluation	1. Do actors accept the roles that have been defined for them during interessement?
Mobilisation of allies	**Design communication** • Meetings • Presentations • Reports • Drawings **Document the completed design**	1. Do the focus actor(s) in the network adequately represent the masses? 2. If so, enrolment becomes active support. 3. If not so then enrolment fails and there is discordance.

The final stage of my data analysis was the cross-nodal level analysis. At this stage data collated at the three nodes were (re)assembled. This involved the juxtaposing of data from the

assemblage stage in order to answer to the third research question. My focus at this stage was on how the design network's structure, stability, and durability were strengthened or weakened by the various associations created during the collaborative design process. This provided answers to the third research question, which sought to find out how students could use Web 2.0 technologies to facilitate the collaborative design process. The audio-taped interview transcripts traced the trajectory of the collaborative design process and relationships and the ties that students established with other actors in the network, such Web 2.0 technologies, design inscriptions, the university LAN. The transcripts also showed other actors which were enrolled into the network and the roles that were assigned to them by the focal actors. These data were also able to demonstrate how the enrolled actors impacted on the collaborative design process. Thus the data provided an empirical basis for discussing both the sociality and materiality of the collaborative design.

3.11 Summary

This chapter mapped out the ANT methodological terrain that I followed in data collection and analysis. The design and conduct of this research was informed by the constructivist ontology of ANT, which demands asymmetry in the way that the effects of social and technical arrangements are handled in the research. The method involves following the actors to depict the reality, because the social does not exist as prior objective reality. One of the advantages of this method is that it allows us to study the way in which actors attempt to create worlds and, consequently, networks. 'Follow the actors' is the motto (Latour, 2005).

The chapter also examined the philosophical assumptions which were considered in this study, and why an ANT methodology was deemed the most suitable in this case. The philosophical section clarified the concepts of ontology and epistemology in ANT to give an enunciated justification of the use of ANT as a methodological framework in studying collaborative design facilitated by Web 2.0 technologies. This was also done to highlight fundamental differences between ANT and previous perspectives that are based on the assumption that the world is 'out there' and not an effect of a construction.

The chapter also provided a discussion on the multiple research methods employed in the constitution and collection of data needed to answer the research questions. At the end of the chapter I elucidate the analytical framework used during data analysis. The analytical

framework was constituted from the key concepts of ANT that I found relevant in the analysis of data. A definition of each concept was given, followed by clarification about usage to answer the research questions. It also elucidated how I analysed the data to give me insights into the worldview of a collaborative design network, and the contributions that this study would make to the theory and practice of collaborative design in a Web 2.0 technology- enhanced environment.

CHAPTER 4

MAPPING THE ACTORS IN THE COLLABORATIVE DESIGN PROCESS

4.1 Introduction

In Chapter 3 I described how I traced the collaborative design network created by actors involved in the collaborative design project. My analysis focuses on the traces that were left by the actors during the collaborative design process. It involves the assemblage of the heterogeneous elements of the design process to establish how Web 2.0 technologies were used as mediators or intermediates during the collaborative design process. The major objective was to identify all the actors and assemble the various networks that they created at each stage of the collaborative design process. I did this to respond to my first critical question, that is;

What Web 2.0 tools are used by students in their collaborative design activities?

The chapter is divided into three sections. The sections are structured in accordance with ANT themes that I used to gather and assemble the events unfolding throughout the design process. The first section (4.2) explains the mapping of the presentation of findings. The second section (4.3) attempts to identify the main actors enrolled into the collaborative design process at each of the three identified nodes, and the relationships that kept them together. The last section (4.4) provides a summary of the main finding presented in the chapter.

4.2 Mapping the presentation of findings

To present the analysis I chose the narrative form, since it allows me to describe facts not simply as such but always as matters of concern, with their mode of assembly and their stabilising mechanisms clearly visible (Latour, 2005). ANT narrative is more than a simple explanation or description. Coming up with such a narrative is therefore not a simple matter, but involves the redrawing or negotiating of the boundaries between the researcher and the collected data. Latour (1997) sees it as both an analytical as well as a practical undertaking of de-scripting of facts that are matters of concern. As I have mentioned earlier on, the analysis is focused on identifying both the conspicuous and inconspicuous actors during the Web 2.0-

facilitated collaborative design process and demonstrating how the process is carried out through understanding the traces left by the actors during their translations.

To begin with, I identify the actors that were enrolled and translated into the collaborative design actor network at all three of the nodes identified in this study, namely the design studio, the university LAN and the Web 2.0 working spaces. This fulfils ANT's first requirement for understanding a network, namely identifying the actors within it (Latour, 2005). Although ANT scholars differentiate between actors and actants, in this study the term 'actor' was used to refer to all the elements that took part or exerted their agency on other elements during the collaborative design process. I took this position mainly because, although in ANT the term 'actants' refers to both human and non-human participants in the network, in many ANT reports this term is used to refer mostly to non-human elements (Shiga, 2006). The fundamental thing is that actors in ANT terms are semiotic entities constituting reality; they act in a space, assembling and constantly creating society (Latour, 2010). They are concrete and real entities, with a defined, full set of features, and are capable of forming solid relations and alliances as they interact in an actor network. However, actors only become real as they become embedded in relationships. These relationships illuminate the identities of the actors. An actor is characterised by its action capacity and its autonomy in decision-making. What is important, at least for me, is to note that whether they are human or non-human. Actors in a network are influenced by their relations with others in the network, and have equal ability and agency in their interactions. In this study, an actor was expected to act within the activities which constitute the collaborative design process, and keep up relations with other actors involved in the design project.

The next requirement of ANT was to understand the actors within the network by identifying the 'work they trace' that is what they do in the network. I did this by first identifying the activities of the actor network that were necessary for actors to traverse the OPP at each stage of the collaborative design project. This involved taking note of the agency of things. According to ANT agency is only made visible in accounts as doing or transforming something. Any actor, human or non-human, will not be able to act if it has not taken position in a bigger configuration that also acts together (Geels, 2005). If it is not possible to make an account of an agency, then an actor is not doing anything and is therefore not an actor in the process. Furthermore, the focus on agency required me to recognise that what made actors do things can have different kinds of figurations (Latour, 2005). In actual fact, one figuration could have

different agencies, as well as one agency possibly having different figurations. I used this tactic to identify actors in order to trace the work they did during the collaborative design project. This approach is a shift from the usual approach of observing static objects such as design object, as this approach focuses on those things that can accommodate the means by which actors manifest their agency (Potts, 2009). However, I found it ambiguous from Latours' description as to who should make the different agencies visible – hether it is the actors being studied or the researcher. My interpretation was that it was my ability to account for an agency that should decide if there was an agency or not. As Potts (2009, p. 287) suggests:

> Knowing who is participating, where they are participating, what systems are supporting them, and what they are doing can help us understand the interaction dynamics that support the creation of this information network.

However, the task of accounting for the actions of non-human actors was not an easy one. Latour (2005), suggests that one way of doing this is by tracing their mediation roles. In addition to the role of making connections, mediation is a concept that draws attention to the organising effects of non-human actors in the design process. As such, viewing Web 2.0 technologies as mediators highlights their role of assembling, and their ability to hold relations in place, and to modify relations to achieve the desired objectives of the actors. In order to explore the actors' role as mediators, Latour (2005) suggests that we engage in empirical metaphysics. Empirical metaphysics entails that we take the actors' own accounts of what they are doing or their 'theories of action' as our starting point in presenting our findings (Latour, 2005, pp. 47, 51). I achieved this by keeping my vocabulary as researcher as minimal as possible and by reporting actors' agencies according to accounts, figurations, and controversies as put forward or portrayed by the actors themselves, since an account can have many other forms than spoken language (Latour, 2005, p. 53). As noted, this was not easy because Latour himself was very elusive on who should make the different agency visible. However, as I indicated earlier on, the responsibility of the map created in this project lies on my shoulders as creator. As such, it was my ability to account for an agency that decided if there was an agency or not.

A distinction should be made between mediators and intermediaries, and Latour (2005, p. 39) points out that "Mediators transform, translate, distort, and modify the meaning or the elements they are supposed to carry", while an intermediary "is what transports meaning or force without transformation: defining its inputs is enough to define its outputs". In other words, an intermediary is anything that circulates between actors and helps define the relation between

them. In this study the notion of intermediary covers diverse and heterogeneous materials such as design sketches, working drawings and texts, among other things that we used during the design process. Intermediaries are the visible effects of the work of assembling heterogeneous materials performed by any actor that seeks to impose its own version of reality on others. They represent the actor in two ways: by standing for them and acting on behalf of them.

Based on the analytical framework discussed in section 3.3, the analysis proceeds as follows: For each node the actors are identified, paying particular attention to what they actually do or actions they take. The role played by an actor in the collaborative design process traces every action made according to the role attributed at the beginning. Furthermore, the analysis illuminates the relationships that the actors or allies established during the translation process as they created a collaborative design actor network in the collaborative design process. Using ANT it was possible to visualise the network created by the various actors from each node, which interact by exchanging information about the design project, tracing and connecting mediators. I used the moments of translation to illuminate how the collaborative design process was enacted in practice. In addition, I also examined the association network formed at each node of the collaborative design process paying particular attention to their evolution, how they restructured themselves as well as whether traversed and infiltrated the other nodes or not.

I observed that mapping out connections among the actors was not at all straightforward. Nevertheless, ANT and its rich vocabulary allowed me to illuminate the ties or associations formed among the heterogonous actors enrolled into the collaborative design project. As Feldman and Pentland (2008) state, I had to focus on performances that resulted in associations or connections that were created between the actors with a view to account for the ostensive aspects of the various sets of associations created. I also had to follow the actors to explain how these associations were stabilised or changed through the strengthening or weakening of the associations respectively. Examination of these associations is important because it is through these associations that the identities and roles of the actors are shaped and reshaped as the activity of the network progresses (Singh-Pillay, 2010). It is in fact these associations which translate actors' practice in a complex web of interconnections, such as in collaborative design. During analysis of the data these associations or ties needed to be examined closely to see how their strengthening or weakening would impact the collaborative design process.

4.3 Actors in collaborative design

The analysis in this section is basically aimed at identifying both the conspicuous and unconspicuous actors as well as spokespersons in the Web 2.0-facilitated collaborative design process. Analysis of the data collected at each of the three identified nodes reveals that many usual and unusual actors were enrolled into the Web 2.0-facilitated collaborative design. These actors included humans (students, lecturers, experts, and technicians) and non-humans (Web 2.0 technologies, design briefs, design artefacts, design sketches and working drawings, etc.). In the following part of this section I present these actors, paying particular attention to their agents as well as the relationships they created, node by node.

4.3.1 Actors in the design studio

The design studio is the traditional physical place where students learn to become design practitioners through learning by doing rather than the more conventional transmission of knowledge content. The centrality of the studio in the teaching and learning of design is based on the fact that it has been identified as a place that supports active learning through interaction and social engagement (Fleischmann, 2014). What makes the studio attractive to design teaching and learning is its student-centredness and opportunity to institute "dialogical learning and teaching" (Danvers, 2003, p. 51). The lecturers, who according to Schön (1985) can be compared to the studio masters, as well as design experts were identified as some of the inconspicuous actors in the design process. The following extract from an interview with the focal actor for a group illustrates the role of the lecturers as actors in the design process:

> *Haa, what usually happens, we have got to see our* ***supervisor*** *[lecturer], then he tell* kuti *[that], he tells us that the things are wrong or the thing were supposed to be in certain … so we go back and meet and then we discuss concerning what we would have been told.* (Interview with focal actor for group A)

The lecturer was responsible for coaching and providing expert help to students throughout the design process. The student leaders (spokespersons) would constantly update the lecturer on the progress of the group, either face to face or sometimes by email. The lecturers provided criticism that helped students to reflect on their actions and decisions. Schön (1985), contends that the studio is not a prototype of only individual work but also of collective action and learning by doing under the guidance and criticism of the master practitioner. This suggests that Ssudio learning is not a two-man band, but involves other key actors. In this study these included the students, lecturers, design briefs and design tools such as drawing instruments,

networked computers and Internet connectivity and the design artefacts. Both students and the lecturer acted through the agency of these non-human actors which were part of the process.

4.3.2 Mapping the relationships of actors at the design studio

In order to start working on the design project the students were asked to form groups of at least four students. Each group selected their own group leader, who in ANT terms became the focal actor of the group. After some briefing with their lecturer each group leader was given the design brief to work on. The group leader assumed a critical position in the group, providing an interface between the group and the lecturer. The group leaders who became the focal actors in each group were responsible for enrolling other actors into the design project. They selected the Web 2.0 technology to be used by the group, and mediated the way the student interpreted the design brief.

The design brief is one of the main actors in the design network; it determines the action to be taken by students and what other actors would enrol into the design project. The lecturers used the design brief to transmit information about the design problem through the focal actor (group leader), who was selected by the lecturers. The design brief could also be viewed as an intermediary that was circulated among actors. Furthermore, the Internet was a critical actor during the design process because it shaped how student designers interpreted the design brief. Through the various Internet search tools and dialogue the student designers were able to come to an agreement on the nature of the design problem.

The project demanded that students used Web 2.0 technology for their design work. This demanded that students had access to Internet connectivity to allow them use the Web 2.0 technology of their choice. This resulted in students enrolling computers and an array of mobile computing devices such as tablet computers, smart phones, and iPads, among other things. Figure 9 below shows these actors and the associations they established.

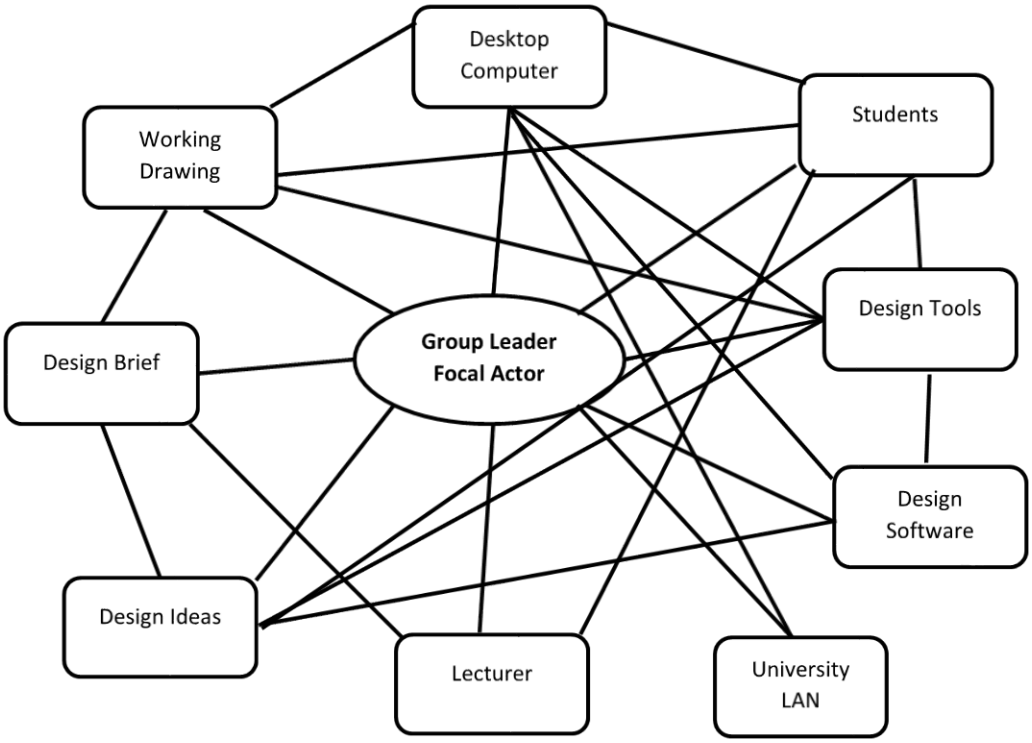

Figure 9: The assertions of actors enrolled at the design studio node

In the design studio many inscription devices were created; these included design representation visuals such as design sketches, working drawing and instructions and procedures for the manufacture of the design artefact. These acted as intermediaries, which transmitted design ideas and caused students to act in a predetermined way as prescribed by the inscription. The link between the students and the computing devices was mediated by the training that students obtained during their first semester of the programme. The level of skills possessed by the students determined the level of use of the devices to access the selected Web 2.0 technology. What students were able to do was also mediated by the availability and size of Internet bandwidth and software on the computers, especially the mobile computing devices. The mobile computing devices and mobile phones used by the student designers needed to be running on an operating system such as Android, that was compatible with Web 2.0 tools.

Internet connectivity mediated the way the actors interacted, when and how they interacted. Internet connectivity was provided through the desktop computers, which were available in the design studio. Students were also able to connect to the Internet through a Wi-Fi that was available at the campus. Students were forced to work 24/7 and through the ubiquitous mobile devices such as smart phones, tablet computers and laptops they were able to participate at their most convenient time and place. The mobile computing devices provided a solution to the reported limited computers, which meant that students would not have worked at their most

convenient times. However, lack of relevant software such as design representation software limited the student designers' capacity to present and illustrate their design ideas, thus in some way limiting the nature of the design solution that students would come up with.

The dialogue that characterises studio learning is made possible by the associations and connections that are created and maintained by the actors. In a Web 2.0-facilitated collaborative design process the dialogue and action by the designers is mediated and transformed by the technology. As we shall see later on in this section, the various web 2.0 technologies that were enrolled into the collaborative design projects created multiple ties with other actors and exerted their agency in ways that shaped the design process in a more dynamic way.

Another conspicuous actor, the university LAN mediated how students would meet and share design ideas. The Wi-Fi allowed students to act from their rooms and make their contribution through various means of communication, including voice calls, WhatsApp and other Web 2.0 technologies (tools) such as Facebook, Twitter and LinkedIn, depending on what the focal actor selected. Information technology provided skills that facilitated how they acted and allowed student flexibility in enrolling various ICT tools for design collaboration. The university LAN thus becomes another critical actor which shaped how the collaborative design process was constituted.

The group leader actor for each group placed himself/ herself as the focal actor in the process. The group leader assumed this critical position in the group by providing an interface between the group and the lecturers. In Latour (2005) terms the group leader assumed the position of the 'spokesperson' of the group. At the group formation stage the focal actor steps up and employs various strategies to enroll other actors into the design group.

4.3.3 Actors at the university LAN node

Presentation of the analysis in this section follows a similar pattern as outlined for the studio node. My analysis revealed a heterogeneous cohort of actors enrolled into the design process at this node. The LAN was the other node where collaborative design activities were carried out. Other than meeting in the physical design studio, students met on the university LAN to perform various design activities. Due to improved connectivity the university LAN has been positioned as one of the most popular meeting places by students. At this working space a

number of actors were enrolled. The focal actor enrolled other group members with their laptops and other mobile computing devices such as iPads, tablet computers, smart phones, Internet connectivity, Wi-Fi, IT skills and training and computer software including Web 2.0 technologies.

4.3.4 Mapping the relationships of actors at the university LAN

Actors at this node induced different agencies upon each other and caused actors to act in various ways during constitution of the collaborative design process. As we have seen with actors enrolled at the design studio node, these actors influence how collaborative design is carried out. .

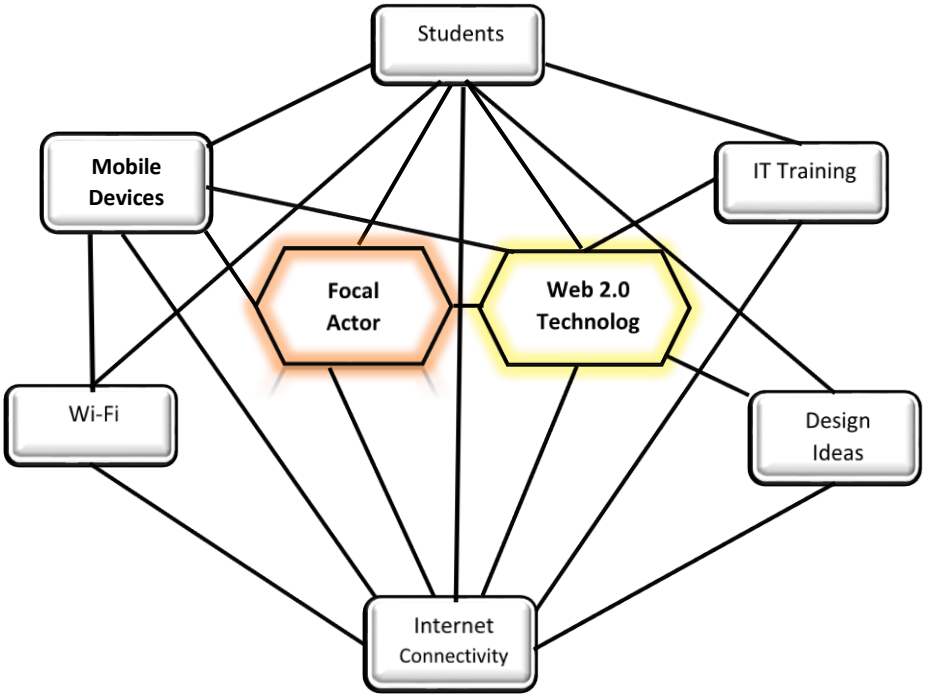

Figure 10: Actors at the University LAN and their associations

Figure 10 above shows the ties formed by the actors that were enrolled by the focal actor at the university LAN during the collaborative design process and the ties between them.

The multifaceted associations formed with the heterogeneous elements during collaborative design reveal the complexity of the LAN node and the competing agencies within its actor network. The Internet connectivity, for example, made students able to work at any time of the day, 24 hours a day and seven days a week, and at any place of their choice – at the university grounds, in the computer laboratories or even in their rooms. The Internet was not a passive medium of communication, rather it was an active participant in the collaborative design process. In ANT terms Internet connectivity then becomes the critical mediator of the design

process. The speed and size of the Internet bandwidth mediated what students could share during the design process and thus shaped how collaborative design was carried out. One student illustrated the agency of the Internet when he gave excuses for not participating:

> *At times, the Internet would refuse to post message and pictures, especially during the day*. (Interview with focal actor for Group A)

Mobile computing devices mediated how and when student designers would meet. The devices allow certain forms and types of information to be shared that is text, video and audio. These devices allowed students to act in ways that defied the limitations of time and distance. The student designers were made to work on the design problem at any time of the day. Some delayed messages, which would be delivered during the night, motivated the student designers to reflect on the design project at such odd times of the day. These messages were accessed by the student designers through their mobile computing devices including iPads, tablets and smart phones. By so doing Web 2.0 technologies were no longer just acting as intermediaries, they were now fully fledged actors with agency. They shaped the way in which students acted and when they acted. They also shaped what information could be shared in the design network.

Web 2.0 technologies such as Facebook went a step further by acting as focal actors in recruiting other actors into the network. By so doing they acted on behalf of the group, enrolling actors and speaking on their behalf. They worked together with the group leaders in identifying and enrolling actors. Students would be encouraged to participate in the design project through the reminders and update messages that would be sent to them through their emails. With Facebook students who were inactive for a time would receive all the messages that were exchanged during their absence. However, loss of connectivity would bring activity to a standstill, and was reported by many students during interviews.

At this node two focal actors emerged: the student group leader continued to establish him/herself as indispensable and the Web 2.0 technology positioned itself as a critical actor by enrolling students to participate in the project. Students found it convenient to participate through Web 2.0 technology platforms such as Facebook and WhatsApp. Web 2.0 technology went further to act as the spokesperson, by providing information to group members and other interested outsiders who were enrolled into the deign project. For example, Facebook would send messages by email to group members. This had the effect of challenging students to make

their own contributions after reading what others had posted. By so doing Facebook directed when and how students would participate in the collaborative design project.

4.3.5 Actors at the Web 2.0 design space node

As I have established in the previous section, the focal actors for each group made use of different Web 2.0 technologies, as required by the design brief. In this section I present the Web 2.0 technologies that were used by the student designers to carry out the various design activities. The data I collected show that the student designers used various Web 2.0 technologies, which included Facebook, WhatsApp, Viber, Skype, Gtalk, Email, MixIt, Twitter, LinkedIn, eText, Google+, and WeChat. Figure 11 is a word cloud illustrating the Web 2.0 technologies. The actors in large print, Facebook and WhatsApp, were those most commonly used.

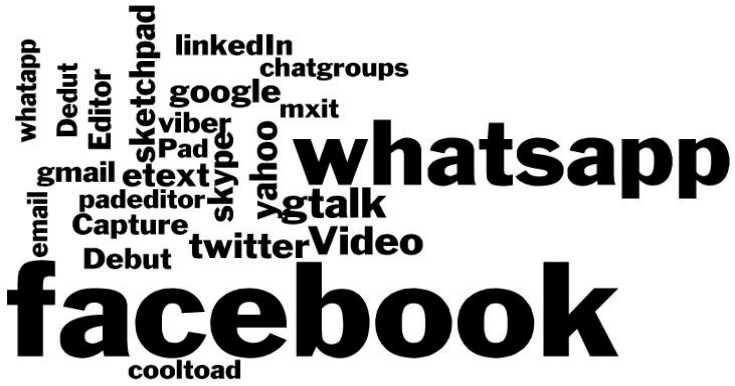

Figure 11: Word cloud of Web 2.0 technologies used student designers

The use of the various Web 2.0 technologies caused the student designers to include more actors that made the use of Web 2.0 technology possible. For example, student designers used various mobile computing options to access the Internet from the university or private mobile network. These included laptops, iPads, tablet computers and smart phones. The university Wi-Fi was the major source of Internet connectivity. However, when students were in places not covered by the university WiFi they continued to use their selected Web 2.0 technology using Internet connectivity provided by private mobile network service providers.

One hidden actor was the students' competence or familiarity with Web 2.0 technologies, which had an influence on their enrolment into the collaborative design network. After students had agreed to work together on the project, through the efforts of the focal actor, the Web 2.0 virtual space become an indispensable design space for the student designers. The ubiquitous

nature of Web 2.0 technology was critical for the enrolment of the technology into the design network. The Web 2.0 platform can be accessed via a multiplicity of computing devices, including desktop computers, laptops, tablets and smart phones. Coupled with the proliferation of mobile computing devices, students had unlimited access to the design project and were able to make their contributions to the design project at anytime and anywhere. However, the use of Web 2.0 technology was not without challenges. Students indicated that Internet connectivity was slow during the day, which made them fail to upload videos and files with graphics since these needed a fast Internet connectivity. Although they had the option of using the mobile Internet connectivity, this was considered to be an expensive option, and many students could not afford to download bandwidth-hungry files such as videos. The challenge of expensive mobile Internet connectivity was eased when students used the option of buying weekly or monthly Internet bundles dedicated to social network software such as WhatsApp and Facebook.

4.3.6 Mapping the relationships of actors at the Web 2.0 working space

Student designers' competence in using Web 2.0 technology was a crucial actor in mediating the association among the student designers and the design problem and other non-human actors. Although a majority of the students indicated that their levels of competence with regard to the use of Web 2.0 technologies was satisfactory, in that it could be classified as intermediate (30) and advanced (17), there were 8 students who indicated that their skill would be classified as basic. Most students (45 out of 55) indicated that they would use most of the listed Web 2.0 technologies for linking up with friends, classmates and relatives. However, analysis of the data shows that the most preferred were Facebook, WhatsApp, Viber, Skype and Google+.

The following excerpt from an interview with a focal actor highlights Web 2.0 technologies which were used in the collaborative design and the ties created:

> *Mostly I use ... technology like Twitter, which I use to share to link with elderly in the field, my role models, role models in our field engineers thus the only platform I use ... sharing what they think, accessing their information, I also use LinkedIn, ... I would be able to view the profiles of those… I will be able to see how they manage to reach ... where they are items of their education, their experience, and their companies. Facebook, I normally use it for linking with classmates; I would be incorporated in their groups to share with them, people share, give their own opinions and Blog Spots*. (Interview with focal actor B,)

Figure 12 shows the relationships and ties created among actors in the collaborative design network at the Web 2.0 design working space.

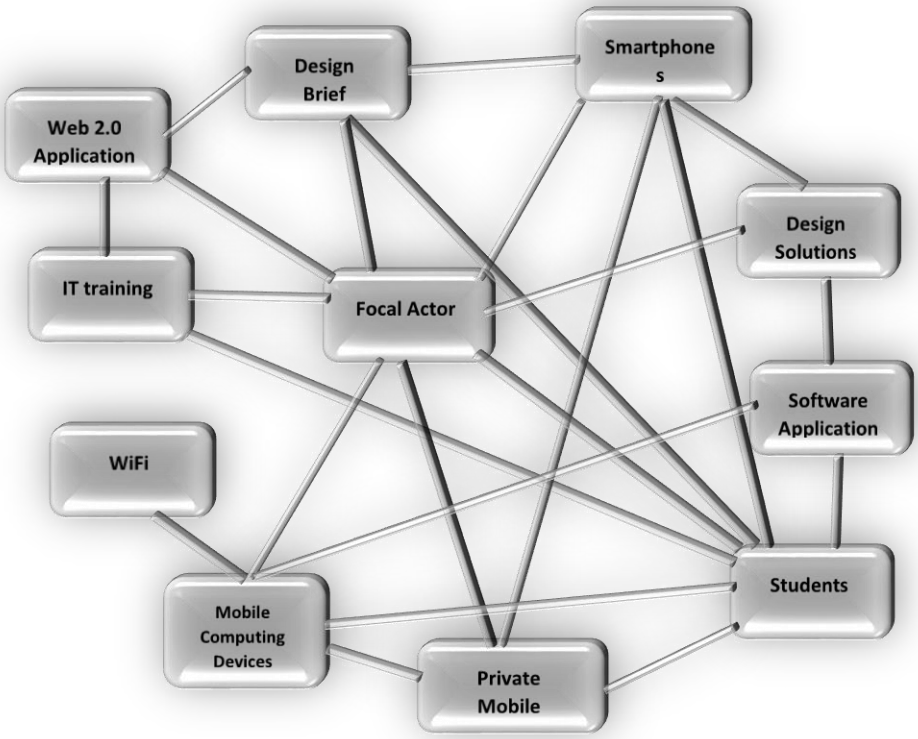

Figure 12: Actors at the Web 2.0 design working space and their associations

The ties among these heterogeneous elements influence how collaborative design is carried out in practice. The various forms of connections, that is one-to-one, one-to-many, many-to-one and many-to-many, as illustrated by the types of communication links formed among actors, allowed more flexible and adaptable interactions among the students. A further dimension of these associations is that they are not bound by distance and time limitations. The Web 2.0 design working space is extending the design process in place and time, thus complementing the design activities carried out in the design studio. As discussed in the literature review chapter, asynchronous online activities in the virtual campus complemented learning in the design studio. However, in contrast, discussions in the conventional design studio take place in small groups, and within the constraints of limited time and space. Using Web 2.0, the face-to-face activities of the conventional design studio are brought to another level. As will be shown later, these technologies mediate the overall collaborative design experience and help the student to develop a deeper sense of collaboration. Data analysis shows that while the students were away from the physical studio environment they could still engage each other

and comment on each other's contributions to the design task as they created a collective understanding of the design problem(s), design context and the whole design process.

At the Web 2.0 working spaces the technology acted as the *'spokesperson'*, which conveyed and transformed information that was shared by the actors. Web 2.0 technologies such as Facebook, for example, would send regular updated messages to designers, which shaped how the collaborative design process proceeded. Such information helped to depict the arguments which the focal actors were pushing for or working against, to interest their allies in the network to accept and develop the agreed upon design solution.

To conclude this section, I would like to note that the analysis shows that there is a myriad of actors, including the material and social elements that were interwoven in the collaborative design process. Analysis of the data revealed that during the Web 2.0 technologies-facilitated collaborative design process there are many actors which are usually taken for granted in many design studies, which were enrolled into the emergent collaborative design network. The nature of relationships formed between students and Web 2.0 technologies promoted and facilitated reflection in action in novel ways, since they support various communication modes and styles – text, pictures and sometimes audio and videos.

4.4 Summary

In this chapter I identified both conspicuous and inconspicuous actors that were enrolled into the Web 2.0-facilitated collaborative design process. In addition to the student designers and the experts they invited, there are various conspicuous and inconspicuous non-human actors enrolled into the Web 2.0-facilitated collaborative design process These included the various Web 2.0 software, of which the most conspicuous were Facebook, WhatsApp and Twitter. There were also some behind the scene actors, for example IT skills training, text and graphics messages, and design sketches, which created multiple associations that constituted the collaborative design network.

These actors were involved in dynamic relationships that shaped their identities in the resulting network of action. Since the network is performative, the actors could only be identified as actors through their agents. ANT's performativity theory puts forward an understanding of action that is essentially dependent upon the structural configuration of the network in which

the action takes place (Santos & Rodrigues, 2009). As Latour (2005) points out, if a group or a 'network' engages in no action, it is therefore not a group or a network.

From these findings I can conclude that the conspicuous human actor is not the only performer during a collaborative design process; and that collaborative design action cannot be predetermined but is enacted through the agency of other actors as they associate in the complex web of relationships. It is evident therefore that collaborative design facilitated by Web 2.0 technologies is a complex cartography in which action is not transparent, but is something that should be traced to be rendered visible. These findings endorse the proposal I made in the literature chapter that there should be a shift in the way we view collaborative design, moving away from viewing it as a rational staged and linear process to seeing it as a collective process that is performed in network(s) constructed by heterogeneous actors.

In the next chapter I present the findings of a cross-nodal analysis of data that shows the relationships and ties created among the actors that constituted the complete Web 2.0-facilitated collaborative design.

CHAPTER 5

MAPPING THE COLLABORATIVE DESIGN PROCESS: A CROSS-NODAL ANALYSIS

5.1Introduction

In the previous chapter I identified the actors and illuminated the relationships of actors at each of the three nodes that constitute the design space. In this chapter I carry out a cross- nodal analysis of the data to illuminate the multiple forms of associations that were formed among the heterogeneous actors across the three nodes. This is important because it is through such associations that the collaborative design process was constituted. The associations formed at the cross-node level map the complete structure of the collaborative design network. The findings provide answers to my second critical questions, namely;

How do students use Web 2.0 tools in the collaborative design process?

Latour's methodological strategy of following the actors inspired my analysis of associations, which I conducted by following the traces that were left by the actors, focusing my attention on identifying which actor was doing what, with who and what their understanding of what they did was. Latour (1996b, p. 94), urges us to "Stick to the actors, my friend, stick to the actors. If they drift, we'll drift along with them". Latour's emphasis shows the importance of watching everything that actors are involved in, because it is only by doing this that we can see how the actors describe the associations they create among themselves. My analysis was focused on describing how the actors related to others, how they translated the interests of others, what they interchanged, and what they represented or said.

The chapter is organised into five sections. In section 5.2 I map the Web 2.0 collaborative design space that was constituted by the relationships created by the actors as they traversed from one node to the other. In section 5.3 I map the relationships formed among actors from the three nodes to illuminate how the collaborative design process was constituted and carried out in practice. My analytical framework focused on elucidating the translations that took place among the actors as they strived to establish a stable collaborative design network. The

moments of translation, that is, problematisation, interessement, enrolment and mobilisation, were central to both the analysis and presentation of the results.

Since according to ANT the establishment of a stable network (the social) entails alignment of interests, illumination of controversies and how they were dealt with was critical to our understanding of how the collaborative design was constituted. Therefore in section 5.4 I present the controversies encountered by the actors, showing how they shaped the collaborative design process. The final section summarises the chapter by bringing to the fore the socio-material context of the collaborative design process as constituted by the array of relationships formed by actors from the three nodes.

5.2Mapping the Web 2.0 collaborative design space

In this section I present an overview of how the Web 2.0 design space was constituted by illuminating the ties that bring together three nodes into an integrated design context. My analysis shows that the Web 2.0-facilitated collaborative design process was constituted at three interconnected nodes, namely the design studio, the university LAN and Web 2.0 working spaces. Figure 5.1 illustrates how these nodes were interconnected to create an integrated design space.

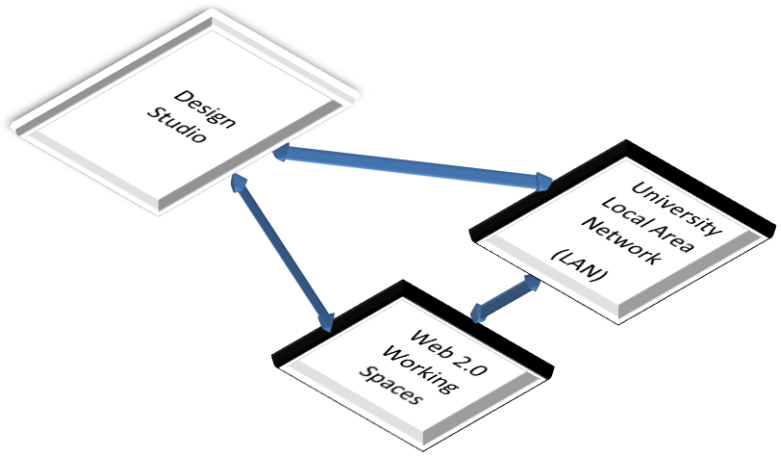

Figure 13: The relationship between the three nodes

These nodes were linked by Internet connectivity provided by the university or sometimes private Internet service providers. Students were seen moving from either the university LAN or the Web 2.0 design spaces into the design studio where the design ideas they generated were materialised and inscribed into different forms of representations, including sketches, working drawings, mock-ups and computer-based simulations, among other forms of inscriptions. It is

also important to note that some of the design took place outside the formal design spaces, in students' rooms at their halls of residence or homes, the library, as well as any other places the students found themselves in. Data show that these informal design learning spaces are becoming commonplace. For example, the widespread wireless access to the campus network and Internet connectivity in homes, coupled with the ever- increasing student ownership of mobile computing devices, means students were able to access their design project anywhere, any time. Furthermore, the use of mobile computing devices has been leveraged by the relevant infrastructure, which includes networking hardware, server systems, software packages and adequate bandwidth provided by the university. This is poised to continue evolving with the advent of Voice over Internet Protocol (VoIP), mobile wireless networking, and emerging technologies.

The design process started with students trying to understand the design brief. The student designers (or design groups) are expected to study the problem that has been given to them. High levels of analysis are required, as well as a lot of fact finding and deep interrogation of the project users. They engaged in heated debate and brainstorming sessions in the design studio, which was carried over the Internet using the university LAN and the Web 2.0 working spaces they created. Students oscillated between the three design working spaces as they toiled to map and identify issues, including limits and constraints, and to understand the design problem from the design brief. This helped the students to craft the vision for the proposed design.

Following the mapping-out exercise the student designers engaged various other non-human actors in the design process to brainstorm, and developed a range of ideas and suggestions for solutions to the identified problems. It was after a protracted dialogue through the Web 2.0 technology that the agreed upon solution was represented through working drawings. The students used the working drawings to come up with mock-ups of the proposed design and models of the solution. These were tried, tested, and refined before the final working drawings were produced. Students were then ready to produce the prototype of the design solution. However, analysis of the production of the prototype and its evaluation was beyond the scope of this study, since issues of intellectual property rights for the design artefact were still being discussed. I was not given permission to analyse in detail the working drawing that detailed the design specifications and how the design artefacts were produced in the Industrial Manufacturing workshop.

The data show that the collaborative design process was carried out in what I can describe as a haphazard, undisciplined and chaotic manner. Students took advantage of the ubiquity of Web 2.0 technology to make their contributions to the project at times that were convenient and aspects of the design process that were of interest to them. Individual student designers popped in with their contributions, especially from the Web 2.0 design space, to any aspect of the design – in some cases in ways that disrupted the course of the design process. Therefore I can conclude that the Web 2.0-facilitated collaborative design learning space and their associated technology have significant effects in shaping the way design is carried out in practice.

The data show that Internet connectivity and the myriad of mobile computing devises as well as the Web 2.0 technology software available to student designers extended the places in which design could be carried out. The Internet has provided a way of linking the design studio and the university LAN and the virtual space created by Web 2.0 technology into one complex design space that engaged the student designers socially and experientially, any time anywhere, on a 24/7 basis. Further, the Web 2.0 technology facilitated the development of a design space that allows for prolonged and communal-based design activities that enabled social interaction and experiential learning to be conducted in a way described by Latour (2008) as designing from anywhere. However, although these activities were carried out haphazardly at each of these nodes, they left traces stored on a platform that all student designers were able to access in real time using different tools. There were countless such tools provided by Web 2.0 which were free of charge (see section 4.4.5) and available for use on personal computers and the various mobile computing devices possessed by the student designers.

The seamless technical interlinking of Web 2.0 technologies and their user-friendliness enabled ideas to circulate freely without barriers in the network. Interaction took place both asynchronously and synchronously at any time, allowing a smooth transition of student designers from the design studio into the Web 2.0 virtual design space. This is against the backdrop of previous forms of computer-mediated interaction among designers in collaborative design projects, which failed to develop interfaces between different contexts and tools.

These observations are an indication that developments in Web 2.0 technology are poised to allow the VDS to evolve into new directions. The combination of advancements in Web 2.0 technologies, digital native users and universities' investments in e-learning and content

management systems are stimulating a radical shift in how design is taught by teachers and practised by students. Literature has established that today's learners are approaching a state of "nomadic ubiquity" (Attali, 2011), with ever-increasing developments in fibre-optic, Wi-Fi, 3G and 4G mobile technologies and their use in conjunction with a range of nomadic devices such as smart phones, tablets and laptop computers. These technologies have made their impact in the traditional classroom, and the design studio has not been spared. However, my findings in this section show that integration of Web 2.0 technology into the design studio to facilitate collaborative design does not follow a clearly defined route that can be resented by a linear model.

5.3Mapping the collaborative design translation

In this section I present the findings pertaining to the design translations that took place in the Web 2.0-facilitated design process. I illuminate the translations to give us a better understanding of how the collaborative design process was constituted. According to ANT the collaborative design can be considered as a translation process through which actors align their interests by associating with other actors in the process. Analytically the process of translation separates into four moments, namely problematisation, interessement, enrolment and mobilisation (Callon, 1986b). I used these moments of translation to organise the presentation of the findings, giving examples of the manifestation of each of the moments from the data I collected in a way that allowed the actors to speak for themselves, as required by ANT methodology.

5.3.1 Problematisation

Problematisation is a critical moment in the design process. This is the stage where designers engage each other in serious dialogue aimed at coming up with some common understanding of the design problem. The data collected show that one student who was given the responsibility to form a group to work on a design problem initiated the collaborative design process. As the focal actor, the student placed himself to become the group leader. The group leader in each of the groups made themselves indispensable to other actors in the group by defining the nature of the problem and suggesting how the problem would be solved Callon, 1986). The following quote from an interview with one of the focal actors illustrates this:

> *In our project, we are designing a vacuum cleaner, which is going to be used specifically in wood workshops, carpentry shops. How we came up with our goals, is one member of our group who suggested the topic then we were all supporting*

what he was saying so thus we came up with our goals. (Interview with Focal Actor B)

This student by default became the spokesperson of the group that he assembled. This actor used the design brief as the problematisation tool. The focal actor analysed the problem situation described in the design brief to understand the problems and came up with a proposed way of solving the problem. The actor used this proposed solution framework to establish roles and identities for other actors in the network. The focal actor's interpretation and understanding of the design brief acted as the OPP which other actors need to pass in order to participate in the project. The focal actor then used various intermediaries to convince others to subscribe to his/her own view and show prospective actors that he/she had the correct view. Web 2.0 technologies and availability of fast Internet connectivity helped the focal actor to create strong ties, which made it easy for them to convince other actors. Most actors that were enrolled into the network were easily convinced or persuaded, because they already had some ties with the focal actor through Web 2.0 social media such as Facebook and Twitter.

Once students agreed to the focal actor's interpretation of the design, the focal actor became the most crucial person to guide other actors to participate in the project. In ANT terms the focal actor becomes indispensable and thus became another OPP, because they made themselves essential for the network (Callon, 1986b). The OPP refers to a point in the design process that can be used to channel actors' interests into one direction. The OPP creates a *black box*, which makes translation processes run automatically without being renegotiated case by case, thus helping to create stable relations that are oriented towards the target. When this OPP is 'black boxed' into a chosen solution later on during the problematisation process, it helped the design translation process to run almost automatically without renegotiations.

5.3.2 Interessement

Interessement involves the establishment of an interface between the interests of the various stakeholders involved in the project as well as strengthening the links between these various interests (Lowe, 1997). It involves convincing other actors that the interests defined by the focal actor are in fact well in line with their own interests. In actual fact successful interessement "confirms the validity of the problematisation and the alliances it implies" (Callon, 1986b, pp. 209-210). Callon (1986b, p. 208), asserts that interessement involves "the

group of actions by which an entity . . . attempts to impose and stabilize the identity of the other actors it defines through its problematisation".

The data reveal the various tactics were employed by the focal actor to encourage other actors to accept their interpretation of the problem. Here I would argue that there were now two focal actors, that is the student as moderator and the Web 2.0 technology that was being used by the actors as the site of the OPP. The following quote illustrates how to become an OPP during the group formation stage:

> *... even your friends they also look for your Facebook page, they request for friendship, they become friends, they become close, but you are separated by oceans* ... (Interview with Focal Actor E)

The focal actors used various tactics to recruit other actors to join them in the design project. In some instances the interessement involved the focal actors creating incentives for other actors such that they were persuaded and motivated to overcome obstacles that stood in their way of becoming a part of the actor network. As required by the design brief, the focal actors in each group employed Web 2.0 technology of their choice to help facilitate the collaborative design process. For example, in networks where Flickr was used the focal actors used tags to give explanations to pictures as a way of providing further information that would help other actors to make decisions. The data show that the targeted actors also made their comments on the pictures, which helped fellow actors to be persuaded to join in the project. By tracing these activities I was able to see how the focal actors used these photos to persuade other students to join them.

As indicated in section 4.3, various Web 2.0 technologies were enrolled and were used skillfully by the focal actors to come up with a group of at least five students. The focal actor's preferred Web 2.0 technology was soon established as another OPP because it became indispensable; without it students would not participate in the project. As shown in section 4.3, most students had some degree of competence in the use of Web 2.0 technologies for other things and using them for design collaboration presented no challenges. The university also offers training in ICT skills, which helps to create strong ties between students and Web 2.0 technologies. These ties were further strengthened by the size of the university bandwidth and the network infrastructure and Wi-Fi that provided good Internet connectivity to students. Interessement was successful as a result of the strong ties that were created among the actors. Through the seamless ties that were created using Facebook and Twitter, actors were able to

agree on working on the suggested project. I explored the different types of ties that were created among these actors earlier, in section 4.3.

5.3.3 Enrolment

Enrolment is the process by which actors constitute others in their own agency. It involves definition of roles of each of the actors in the newly created actor network. It also involves a set of strategies used by the focal actor to convince other actors to embrace the underlying ideas of the emerging actor network and make them active participants in the project. Callon (1986b, p. 211), asserts that enrolment includes "the group of multilateral negotiations, trials of strength and tricks that accompany the interessement and enable them to succeed." At this moment the focus of my analysis was on seeing how actors showed their willingness to anchor themselves to the project (Callon, 1986b).

Once the actors were recruited through the interessement techniques employed by the focal actor, as I described in the section above, next was to watch how these actors would invest their interest in the project through taking up the roles assigned to them by the focal actor as a new network of interests was generated. As I have argued in the literature review, enrolment involves the creation of an alliance network, with the aim of building up agreement among the actors concerning their interests. In the design practice enrolment further strengthens the OPP as actors strengthen the created network by accepting the focal actors' definition of the design problem that would have been agreed upon at during the problematisation stage and made cogent during interessement. At this stage the focal actor bestows qualities and motivations to actors and establishes roles that actors need to play for the network to achieve its goals.

The enrolment of actors was visible through various indicators, which included students posting their contributions; and by adding photos to the community as they responded to calls made by the focal actor. Actors anchored themselves to the network. As the collaborative design project progressed, the frequency of visits and contributions made by actors increased. Enrolment did not only mean students reading and viewing the postings but encouraging others to make contributions to the discussion. It is such mediated interactions between actors that need to be uncovered in order for us to understand the kinds of interactions that lead to successful collaborative design networks or cause them to fail. The concentration of activity in the Web 2.0 spaces that results in the increased density of ties created among actors allows us

to see how these participants work together to help shape or reshape the collaborative design process.

The ability of actors to post their comments and upload pictures on Facebook, Twitter and other Web 2.0 technologies marked the first step toward transforming the group of students into a network. The ties that existed between the students and the various Web 2.0 technologies facilitated the design translations that took place. Students knew how to add comments, tags and photos to the pool. Furthermore, the interface and structure of the working space created by the Web 2.0 technologies aided in the representation of design information to the actors in the network. A close analysis of the data reveals incidences of weakening of ties among human actors themselves as well as ties between Web 2.0 technologies, due to frequent loss of electricity resulting in loss of Internet connectivity. During such instances the network would be brought to a halt and the project put into disarray. There would be no network to talk about. However, this would happen for a short period since other alternative actors would be enrolled to perform the same function. In the case of loss of electricity, electric generators would be employed to provide power to university servers, and connectivity would be restored. At the same time students would enrol mobile computing devices such as iPads, tablet computers and their smart phones to access the Internet through mobile network service providers. This introduced another critical actor into the collaborative design actor network, which ensures connections among the actors are maintained.

A further analysis of the data reveals issues of prescription and inscription, which will give us insight into how the actors' experiences during the collaborative design process were bound by the interface conventions and system structures of these Web 2.0 technologies. The issues are critical in illustrating how actors were turning raw data (as it was contributed by other actors) into actionable information during the collaborative design process. As I noted in the literature review, prescription is defined as "what the device allows or forbids from the actors" (Akrich & Latour, 1992, p. 15), and inscription refers to the visual artefacts that are created by actors as part of their knowledge work (Latour, 1987b, p. 218). Design working drawings are but one inscription used by actors to shape the design and the relationships among actors; others include work procedures and practices. The alliances formed with viable inscriptions were some of the strategies used by the focal actors to enrol other students to join in the collaborative design project.

5.3.4 Mobilisation

According to Callon (1986b), mobilisation involves the focal actor's use of a set of tactics to ensure that allies act in agreement and do not betray the focal actor's interests. In a collaborative design process mobilisation entails monitoring of the various interests so that they remain more or less stable as the network gains wider acceptance, by making durable and potentially irreversible translations (Mouritsen, Larsen, & Bukh, 2001). Irreversibility in collaborative design refers to a situation where it becomes impossible to go back to a point where alternative possibilities exist (Callon, 1991). Through the stages of problematisation, interessement and enrolment the agreed upon solution will have been sealed and in ANT terms black boxed into working drawings which inscribe certain roles and work procedures among the actors. Such levels of stability would mean that the actor network and its underlying ideas have become institutionalised and are no longer seen as controversial.

The data revealed some mobilisation acts by the focal actors they worked using the Web 2.0 technologies to get other actors to act according to the agreed plan as the new design work start to realise the chosen solution to the design problem. When asked about their role in the project one, of the focal actors said:

> *My major contribution, I am the group leader, we are doing the project being four and I am the group leader. So my role is to mobilise people so that we can work on a particular work together, so usually I am the one who does the typing of the project, the editing in case we download something from the Internet, thus my job*. (See interview with Focal actor A)

The extract above shows that at this stage the focal actor would have been endorsed to be the spokesperson of the group, with responsibility to explain and answer all questions pertaining to the project to outsiders and other stakeholders, including their lecturer. Data analysis shows that the spokespersons from the different groups used different Web 2.0 technologies, including Facebook, Twitter and Flickr, to encourage other students to participate and execute their roles. A closer look at the Web 2.0 work space revealed that for Flickr users the use of tags as devices for mobilising actors could be traced, to see the agency that it caused to other actors. Students would tag photos to be more descriptive and enable searching key words. This was particularly evidenced by the number of 'design' tags that were posted to Flickr, the most popular Web 2.0 technology used by students to share their design-related pictures and photos.

Most of the attention of the spokesperson/focal actor went to caring for the emerging group and answering members' questions or queries. Students were offered opportunities to plan their

own actions on the project and to invite selected members to participate in other actions. This was done through sending private messages to target members through their inboxes for Facebook and WhatsApp users. Sub-groups were formed within their private spaces, but working on the same bigger project. Various techniques, including incentive schemes, were used to make sure that students maintained their interest in working on the project. One example was when the spokesperson in one of the groups made a call to members of the group to share their ideas and pictures of their design ideas online.

SM: This is what I have for the group, guys say something. How is it guys?

MM: This is what I have guys say something. How is it?

TH: This is powerful Mufana [not actual name, but actual name mentioned]
SM: Its gud thanx w yr efort we apreciate it.

MMM: I wil also upload mine but I think of Monalisa is good cz it has three stages hence I wil download it and make some editions using powerpoint. On Monday we should start drawings, so we shld discuss abt materials needed.

MMM: I think we shld nw agree on the photos we uploaded so that we come with the best wc we wl use to present everybody effort is appreciated.

Extract of Facebook Conversations by Group A

The call was successful in attracting multiple ideas and pictures that created a vibrant atmosphere on the design network.

In this section I demonstrated that the Web 2.0 technology-facilitated collaborative design process took place through translation, which is a process aimed at influencing relationships between the human and non-human actors to enrol and interest other actors to be in the network and to make it stable by solving controversies. As affirmed by Akrich et al. (2002), the design process is always in search of allies to support the network. The structure of the design process is the outcome of a translation process in which humans and non-human actors align their interest in an actor network. The process emerges from a complex dialogue among multiple actors who are enrolled into the network, and from the ability of the focal actor to exercise power against competing and divergent interests among the actors. None can predict how the process will unfold, because as we have seen the process was described as a back and forth process where different actors intervene and contribute to the design project from different

points. As such the design process is about collaboration in a context that is not pre-planned or anticipated.

Design processes are a mishmash of decisions that are taken to take actions that are not planned nor can be predicted in any mechanical way (Akrich et al., 2002). In the process an endless number of actors are needed "to enrol others so that they participate in the construction of the fact; to control their behaviour in order to make their actions predictable" (Latour, 1987b, p. 108). The process of interessing, mobilising, and enrolling allies in the network, as well as the process of moving across the fluid boundaries to make the network bigger and more stable, contribute to the success of a design (Gasparin, 2014b).

The dynamics involved in a Web 2.0 technology-facilitated collaborative project draw our attention to the need to look at the process of translation in a different way. My analysis of the data that speaks to translation revealed that design translation involved constant negotiations among human actors and delegates of non-human actors to establish a common set of shared understandings. These shared understandings made way to some common meanings of the design problem at hand. The process of dialogue and negotiation that led to these common understandings was mediated by the focal actor, who was functionally indispensable to the creation and performance of a network. This actor became the first OPP through which all the other actors had to pass in order to get enrolled and mobilised into the collaborative design network.

The outcome of a successful translation was a collaborative design actor network that was characterised by aligned interests. The degree of alignment of actors' interests depicted the level of agreement achieved by the actors, which pointed to the level of convergence in the network. These agreements were quickly inscribed into something durable (Law, 1992). These inscriptions included the design sketches representing the design solutions, working drawings, working procedures, lists of materials and design artefacts that provide a solution to the design problem. These intermediaries were black boxed, implying that once they were produced they would not be questioned; students would just follow them religiously in order to come up with the design artefact.

The whole host of new and unfamiliar actors such as smart phones, iPads, social applications, and Wi-Fi broadband among others, transformed the way conspicuous actors could be enrolled

and mobilised into the collaborative design network with respect to time and distance. The enrolment of the various mobile computing devices into the collaborative design was the root of disruption or the opening of the previously stable black box of the collaborative design actor network relationships. Our understanding of the collaborative design actor network needs to be reconfigured to accommodate the new actors who would normally not be considered where collaborative design is discussed.

The associations formed during the collaborative design translation were manifested through the various strategies, which were used by the focal actors to interest and enrol other actors into the network to play the critical roles assigned to them. Rapport between the focal actor and other students emerged as the cement that would glue the participants together. The principal actor would use an array of communication tools, including mobile phones, Web 2.0 technologies, and social media such as Facebook, Twitter, Flickr and WhatsApp to get hold of other actors perceived to be potential partners in the design project. This was not an easy task. The focal actor sometimes had to bear with criticisms, and in some instances some rejection of his/her ideas. It is these fluid associations that constituted the collaborative design translation. The associations revealed how the collaborative design was performed and also reflected how the socio-material realities context of the collaborative design emerged through the created network. In ANT terms this socio-material reality which is created by the actors is the ontology or reality of the network (Singh-Pillay, 2010).

Furthermore, the translation stages were rather more fluid and interwoven than reflected by Callon's analytical model. I found that the stages were accomplished in a fluid manner as the order of things was created and maintained by the actors' strategic acts of negotiating and manoeuvring one another to form a network of aligned associates. For example, an analytical frame that would limit analysis to a single focal actor with a single OPP would have been too simplistic for the collaborative design translation that transpired in this context. As I have demonstrated, many other actors were regarded as focal actors. Acts of problematisation were uncounted at almost all stages of the design problem. Furthermore, the same sources of problematisation would be influential in prompting multiple actors to play the role of focal actors and enrol new actors throughout the stages of the design process. The allies were not remaining fixed at one node; as they moved from one node to another, their roles changed. Actors were not preconstituted elements, but were constantly modified by the translation

process. The weight of what counts or what does not count was never predetermined (Latour, 1991a), but was the result of the translation process.

From the analysis it is evident that translation played a critical role in the enrolment process. The spokesperson worked to translate the topographies of the network, while the student designers worked towards mediating them to their allies as they both worked to strengthen the network of allies. Where there were many translations among the actors, the design solution was understood better. The students showed commitment to the design solution and were easily mobilised to work on the solution. Thus the design solution became an OPP, with all the student designers showing a higher degree of commitment to work on the project. Therefore it can be concluded that prolonged discussions create more links, with a higher likelihood that the agreed upon programme of action would be understood by all actors and mediated successfully by the technology, that is, Web 2.0 technology.

The role of the spokesperson, either the student leader or the Web 2.0 technology used, was critical and helped in the formation and stabilisation of the network. When the actors become inactive or dormant, the spokesperson used various strategies to persuade and motivate the actors to participate in the project. Students pointed out that the constant updates they received from Facebook (through their emails, for example) acted as stimulants to them and shaped the way in which they participated in the design process. The human spokesperson worked hard to mobilise other students to take part during the process to avoid the collapse of the network. The spokesperson also mobilised and delegated functions to Web 2.0 technologies (the non-human actors) to successfully enrol other students to participate in their design project. It is, however, not clear whether students acted because they were stimulated by the spokesperson or whether it was through the agency of Web 2.0 technology or both.

To ensure actors did not leave the collaborative design network, the spokesperson sometimes would use acts of black boxing emerging networks by employing some degree of authority and power over actors. Although to a large extent the data show that this resulted in some order and stability in the design process, resistance was also evident. Furthermore, exercise of power had the effect of closing dialogue too early, leaving some actors with unanswered questions. So instead of bringing the desired stability into the design process, the exercise of power led to some decisions being made prematurely, leading to some despondence among the actors. This was detrimental to the design process, as in some cases it was a source of conflict that would

result in some destabilisation effects on the collaborative design process. This is to be expected because the collaborative design process presented in this section is essentially dynamic, complex, unwieldy and full of wild and unanticipated relations and entities that emerge as a consequence of any practice. This implies that collaborative design practices are always subject to modification, and this is highly explosive in an environment of a multiplicity of actors, where none is in charge and the outcome is uncertain. Deleuze and Guattari (1987), argue that any such practice or event is pregnant with multiple 'lines of flight' that escape the designated stratified and ordered space.

I established in the literature review that collaborative design involves complex interactions among heterogeneous actors who form dynamic networked environments including dialogue, negotiations, agreements, disagreements and coordination collaboration (Ouertani, Gzara, & Ris, 2007). Owing to the multi-actor interactions involved in the created design network, controversies are bound to occur. The findings of this study show that this is mainly because each actor is entitled to their own point of view, concerns and objectives regarding the design project. In the next section I develop this issue by illuminating the controversies which were encountered by the actors during the enactment of their roles during the collaborative design process.

5.4 Mapping sources of uncertainty in Web 2.0-facilitated collaborative design

The findings presented in the previous sections show that Web 2.0 technology-facilitated collaborative design is not a linear and straightforward process. It is a complex hodgepodge of tension, conflict, uncertainties, and power dynamics that momentarily bind together and hold the practice of design at the various stages of the design process. One fundamental property of collaborative design is that at the start of the project there are many uncertainties that designers have to deal with. As the project proceeds the emerging network's complexity increases and thus different sources of uncertainties appear. These uncertainties raise controversy on how they could be coordinated to ensure that the network achieves its agreed goals or at least remains stable. For us to have a full understanding of how this process is constituted, one possible entry point is for us to focus on the sources of uncertainties in a Web 2.0 facilitated collaborative design process' In this section I expand on the uncertainties encountered by actors during the collaborative design project, showing how they helped to shape how the

collaborative design process was constituted and carried out in practice. As such, my analytical questions on design controversy were not to reassert or to prove that collaborative design is a controversial process since in this a given. Rather, my analytical questions aimed at showing which uncertainties were encountered and how they shaped the constitution of the collaborative design process. I used four of Latour's (2005) five sources of uncertainty , namely; group formation, nature of action, nature of objects and nature of facts versus matters of concern, to distill from the data the uncertainties faced by the student designers.

Web 2.0-fscilitated collaborative design presents designers with a number of uncertainties. My ANT analytical framework derived from Latour (2005)'s conception of uncertainty shows that these uncertainties can be summarised in the following five questions.

- What is the problem being solved?
- Who is required to act on the problem?
- When are they required to act on the problem?
- How are they supposed to act?
- What is the right solution to the problem?

Figure 14 below illustrates how these uncertainties are related to the design process.

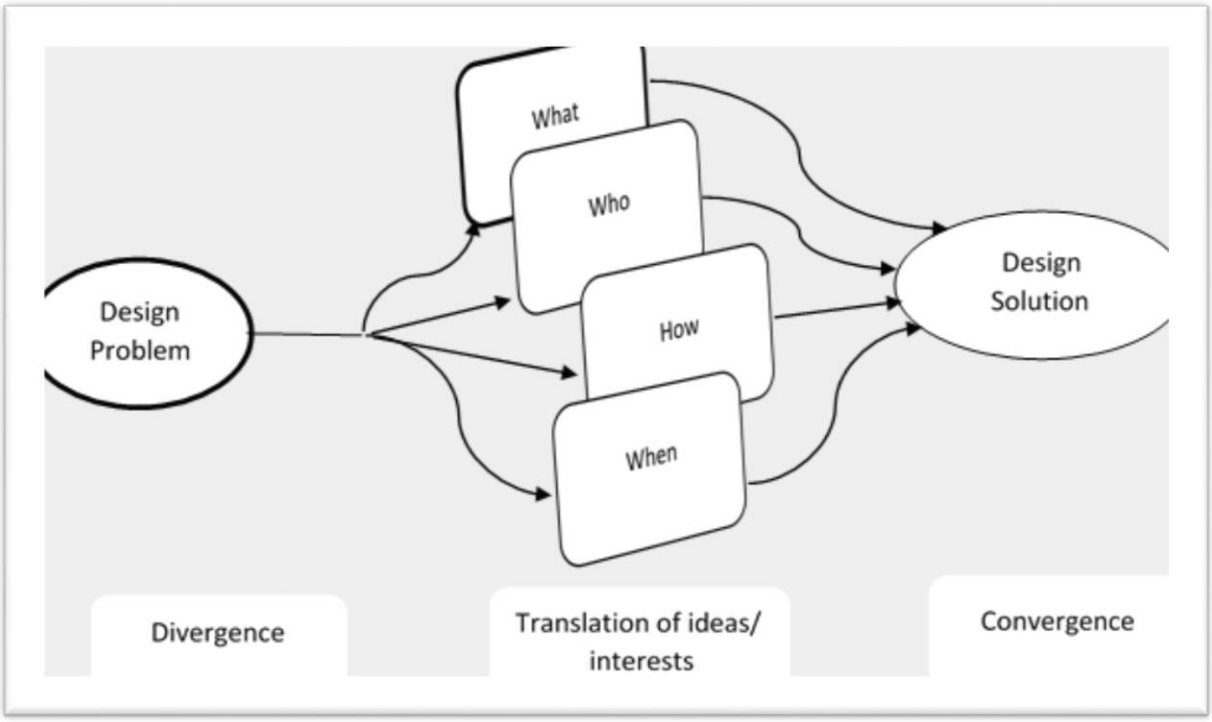

Figure 14: Uncertainties experienced in Web 2.0 facilitated collaborative design.

I elucidate these uncertainties using the traces that were left by the actors during the design process, which I assembled from my analysis.

(i) What is the problem being solved?

After receiving the design brief from their lecturer student showed a general lack of clarity of what the task ahead of them demanded. In the first place, there was uncertainty surrounding what constitutes the best way to define the design problem. This is demonstrated by the following two quotations from Facebook contributions and an interview with one of the spokespersons.

> *Okay guys rather than arguing on which project to venture into, I think let's compare the ideas that we hve [have] on grnd [ground] and try to derive senses from them, the one which we can easily derive senses from is prbly [probably] the best.* (Facebook quotation)

> *Em! Yaah, this actually wasn't the first one, firstly the idea was for a bin to use in the workshop for collecting wood shavings, but then we noticed that it might not be of much value to many people and even if we were looking at making a business out of that it's likely to produce little income. So we then had to change looking at something chokuti [we can say] after producing it can help us come up with an industry that can create employment at the same time tichishandisa [using] technology to improve the product*. (Interview with group spokesperson C)

These quotations show that student designers had different conceptions on the design problem and how they thought the design sought to solve. This uncertainty resulted in heated debate through the different Web 2.0 platforms which were used by student designers to share design information and make their contributions to the design process. This affirms the assertion that design problems can never be presented as matters of fact but rather as matters of concern which require exposure to different points of view for designers to have a fuller understanding of the problem. It is only when the problem is thoroughly discussed that a satisficing or a 'good enough' solution can be achieved.

(ii) Who is required to act on the problem?

The uncertainty based on who is required to act refers to the actors' identity and the roles assigned to them. ANT argues that an actor is defined by its action. It was not clear from the beginning of the design process as to which actor was going to take up which roles. This uncertainty was worsened by the heterogeneity in actors displayed by Web 2.0 facilitated collaborative design networks. Action in a network is problematic in the sense that it is not

always the results of intensions. Actors can act as a result of forces exerted upon them by other actors in the network. As a result actors might end up doing things that they have never imagined at the beginning of the process. This uncertainty is also a result of ANT's position that objects too have agency and no one can predict what they can course other actors to do because action is a result of associations created among the actors in a network.

(iii) How are they supposed to act?

Another source of uncertainty encountered was around which Web 2.0 technology to use, which introduced uncertainty among student designers regarding their ability to use the technology. The association between technology usage and student designers' skills as an indication of the tension and contradictory cartography during the collaborative design process is illustrated by the following statements made by some student designers during interviews:
Facebook is difficult to use for me …. I didn't want to use it for learning purposes…. I think you know how difficult it is to exchange designs using Facebook (Interview with Spokesperson group A)

> *We have different level of Internet access, we have different computers skills, and some of us don't know how to use this Facebook* (Interview with Spokesperson for Spokesperson for B)

These two quotations point to the problematic nature of using Web 2.0 technologies such as Facebook, especially with students who had limited skills to use the technology. Even where the student had the skills, other factors come into play, for example poor Internet connectivity and the high cost of connectivity. The following quotations illustrate other factors that shaped how students used Web 2.0 during the design process:

> *The Internet on the phone, we are not always connected. It's like if we are not here, this needs money in the phone, but once we get to college we connect through the WiFi so it will be, there will be no charge for that, but when we go back supposing you don't have money in your pocket thus when you face challenges, but so far I would say there are no cases when we spend the whole day without connection.* (Interview with Spokesperson for Spokesperson for C*)*

> *… at least we have got a Wi-Fi here, at times it will be congested that we find it not easy to go through.* (Interview with Spokesperson for group E)

> *There was also network problems with the tool and at times we could fail to communicate to other group members because of network.* (Comment from questionnaire)

Another critical point of uncertainty was the shortage of computers in the design studio:
Here at HIT computers are sort of shortage, other people will not allow other people to get chance to use the computers, there are some who continue to use computers from morning till evening, sometimes if you want to share information through Facebook you end up losing hope. (Interview with Spokesperson for group E)

Furthermore, student designers indicated that there was none of the relevant software they needed for their design work. Such challenges tended to weaken the ties created among actors, thus affecting how the collaborative design process was carried out. However, the network was kept together due to the ubiquitous nature of Web 2.0 technology. When the university Internet connectivity was not available, student designers were able to connect through other options such as mobile network operators. New actors including smart phones and tablet computers were enrolled into the network. This ensured that the ties created among student designers were kept live.

The complexity of the uncertainty about participation in Web 2.0-facilitated collaborative design worsened by the observation these actors' agents were not limited by time and distance. Student designers where able to participate anytime anywhere using mobile internet connectivity. The uncertainty in participation was thus made more complex, which made the task of assigning roles to actors and the coordination and motivation of the other actors to take up their assigned roles difficult. The spokespersons had a difficult time trying to assign roles to the other members in their groups. In many cases a few individuals who had developed strong tires with the mediating actors such as the internet and had constant connectivity ended up taking very role in the network.

(iv) When are they acting and with what?

Web 2.0 introduces a design working space where it is difficult to predict when one would participate in the design process. Data collected show that participation was 24/7 and actors would participate from any distance. There are many (f)actors which influenced when and how actors used to act on the design problem. Connectivity was poor during the day, so many Facebook messages were sent during the night with some delivered in the early hours of a new day. Many student designer complained about messages which were never delivered on

WhatsApp. Sometimes other actors would be made to wait long period before they would get a response from a one member of the group, resulting in the network being temporarily dissolved. Where the network continued to function without other key actors, the network would be forced to look back to some aspects of the design, the other member rejoined the group. This has both negative and positive implications to the design process. On one hand this allowed student designers to reflect on their work and on the other hand some student designers felt that this was time wasting.

What student would use to act presented another form of uncertainty. For example, the enrolment of Web 2.0 technology created uncertainty at the LAN node in respect of students' computer literacy skills. However, a mediating actor in the form of training was also introduced to impart the relevant skills, qualities and motivations. For example one spokesperson had this to say:

> *It's demeaning and embarrassing for us …. I didn't ask to be placed at a previously disadvantaged school …. You don't know how hard it is to work in the conditions I face* (Interview with the Spokesperson for Group B)

The arbitrary association between training and best practice would help ease uncertainty over the student designers' ability to use the right technology to communicate.

(v) What is the right solution to the problem?

In the absence of the physical design space to test the functionality of the proposed solution, uncertainty over the functionality of the proposed solution increases. There was evidence of uncertainty as to how well the design artefact would perform its intended functions, as well as whether it was going to be accepted by the users. The following quote from an interview with focal actor B illustrates this uncertainty:

> *You know what, I myself I even sometimes doubted if we were going to come up with a cleaner. Even after we had agreed on the solution still I was not sure the thing was going to work, everything was in the air on the net* (Interview with Spokesperson for group A)

This question could never be answered with certainty at the beginning of the design process, or even at the end of it. Instead, this uncertainty points to one of the key actors who was left behind during the early stages of the collaborative design process.

Although the analysis shows that many different actors were enrolled into the design network, not all key actors were enrolled. Users, who constitute one of the key stakeholders, were left out of this design translation. The observation was that the design translation process becomes problematic if some critical actors are left behind. The problematisation dialogue should have included any analysis of the design problem described in the design brief, with the view to identify the intended user community of the design artefact, so that linkages could have been created between the design problem and the user community. The uncertainty about how well the end product of collaborative design would satisfy the user community cannot be resolved at the beginning of the project; the emerging character of the object of design can be addressed by creating ties between the designers and their clients.

The discussion in this section revealed sources of uncertainties, as described by Latour (2005), and how these influenced the way Web 2.0 collaborative design was carried out.

5.5 Summary

In this chapter I carried out a cross-nodal analysis of the data to illuminate how the Web 2.0-facilitated collaborative design was constituted and carried out in practice. I examined the ways in which the networks of relations were composed and came into being, and how they were made durable over time as the actors went through ANT's stages of translation. My analysis has demonstrated that Web 2.0-facilitated collaborative design takes place in a networked design space characterised by fluidity, flexibility and openness. The analysis shows that student designers need minimal technology skills to be able to leverage Web 2.0 technology to facilitate their enactment of roles in the collaborative design process. This was coupled with the myriad of technologies that could be used to by the student designers to access this new and emerging design space, including personal computers, laptops, tablets and smart phones. The data also show that Web 2.0 technology makes available to student designers a toolkit of communication software including Facebook, Twitter and LinkedIn, which can be used by student designers to enact their assigned roles in the collaborative design process. I therefore conclude that Web 2.0 technology facilitates designing as an open process, by reducing the barriers between design tools and the designers. Web 2.0 social software pushes forward the technological boundaries, providing collaborative technologies that can be used with minimal technology skill, and seamlessly interconnected and combined with other tools as required. Their ubiquitous nature ensures that students can remain engaged on their design project on or off campus.

This connectedness has unlocked many possibilities for growth in the way collaboration is conducted. Actors traversed the nodes in an ad hoc manor as they enacted their assigned role in the collaborative design process. The actors could come together to form temporary networks in assemblages of relations specific to particular stages of the collaborative design process that constituted the broader process. The process was socialised and made coherent at the three identified nodes after having been initiated in a studio or engineering workshop. Therefore, it can be concluded that Web 2.0-facilitated collaborative design is not a static but rather a dynamic process.

The translation process was directed by one or more actors who acted as the spokesperson and led each emergent network. Web 2.0-facilitated collaborative design is a network formation process through the alignment of actors' interests in translation. I also noted that some of the associations were complementary while others were contradictory, thus leading to either convergence or divergence in the collaborative design network. Whether complementary or contradictory, the associations formed among the actors exposed the different roles or work done by the various actors during the collaborative design process. The associations provided me with insight into what shapes a Web 2.0-facilitated collaborative design process, which in my view is critical in the teaching and learning of design.

I also noted that the association formed among actors involved negotiations and compromises/ trade-offs by them with regard to the goals to be achieved. In some cases the associations formed exposed the contradictory cartographies and the tension that sometimes characterises collaborative design networks. These controversies resulted in some uneasiness and contradictions among actors within the network.

In the next chapter I use the relevant ANT resources assembled in the literature review to reflect on the findings to answer the third research question posed in this study.

CHAPTER 6

MAPPING THE ROLE OF WEB 2.0 TECHNOLOGY IN COLLABORATIVE DESIGN

> "Real artefacts are always part of institutions, trembling in their mixed status as mediators, mobilizing faraway lands and people, ready to become people or things, not knowing if they are composed of one or many, of a black box counting for one or of a labyrinth concealing multitudes." *(Latour, 1999b, p. 193)*

6.1 Introduction

In this study I have investigated the collaborative design process in action, giving particular attention to the role of Web 2.0 technologies during the process. In Chapters 4 and 5 I traced the trajectory of the collaborative design process and assembled the heterogeneous networks that constituted the collaborative design process in a Web 2.0 technology environment. In this chapter I present the findings that map the role played by the Web 2.0 technology used during the collaborative design process. I use the ANT resources I assembled in the literature review to reflect on the findings to answer the third research question I posed in this study: How does Web 2.0 technology facilitate the collaborative design process?

In order to have a complete picture of the role played by Web 2.0 technology in the collaborative design process, I performed a cross-nodal analysis of the data gathered. The chapter is organised into two main sections:

1. Mapping the role of Web 2.0 technology during the design translation process; and
2. Mapping the role of Web 2.0 technology in design controversy.

ANT offers a suitable framework for tracing the role of Web 2.0 technology in the collaborative design process. From an ANT perspective the findings I presented in Chapters 4 and 5 demand that we consider collaborative design as a network effect. Therefore the role of Web 2.0 technology could not be considered outside the network context. It was imperative that I considered the role of Web 2.0 in relation to all the other actors involved in the collaborative design process, namely the student designers, the group leaders, Internet connectivity and computer devices, including laptops and tablet computers, among other actors.

ANT offers us a predominance of vocabulary for understanding the role of artefacts such as Web 2.0 technology in an actor network like collaborative design. For this study Latour's principle of symmetry offers a unique way of developing a more material way of thinking about Web 2.0 technology. In his principle of symmetry Latour (2005) proposes treating people and things (that is, the humans and non-humans) symmetrically, since actions are usually performed through the associations made between the human and non-human elements of society. He argues that if we are to understand what is actually happening in society, there should be no a priori distinctions between human and non-human elements. Latour (2005) strongly argues that not only humans but also non-humans, or conjunctions of humans and non-humans, should be considered as actors in a network of relations. ANT not only argues that things (Web 2.0) have a capacity to act, but also that they have this capacity by virtue of their materiality: their concrete '*thingly*' presence.

6.2 Mapping the role of Web 2.0 during the design translation process

My illumination of the role played by Web 2.0 in collaborative design is focused on providing an explanation of how the collaborative design process developed around Web 2.0 technology was constituted and how the emerging network configuration was influenced by Web 2.0 technology. Following ANT's principle of symmetry, this study recognises that technology and humans share capacity to influence the collaborative design process. As Yaneva (2009, p. 282) notes, Web 2.0 technologies in collaborative design are instrumental in:

> Producing additional attachments that make a variety of actors assemble, forming different groupings and assembling social diversity ... [by] linking disparate heterogeneous elements and effects, thus entering a game of producing, adjusting and enacting the social.

These observations of how Web 2.0 technologies frame and afford particular social practices and values are supported by other STS research around many technologies such as washing machines and showers (Allon & Sofoulis, 2006; Shove, Watson, Hand, & Ingram, 2008).

What makes the role of Web 2.0 in collaborative design critical is the observation made by Latour (2007) that groups are not held together by existing commitments, but are created and held together in a network by mediators. In mapping the role played by Web 2.0 technology as conspicuous actors in the collaborative design process, the following quotation by Latour (1999b) was instrumental:

> Real artefacts are always part of institutions, trembling in their mixed status as mediators, mobilizing faraway lands and people, ready to become people or things, not knowing if they are composed of one or many, of a black box counting for one or of a labyrinth concealing multitudes.

As I have established in Chapter 5, Web 2.0 technology-facilitated collaborative design is a dynamic networking process involving heterogeneous actors who are engaged in working out the solution to a design problem. In other words, collaborative design can be viewed as a translation process in which actors negotiate to establish a common set of definitions and meaning to allow dialogue and common understanding of the design problem and its solution. During the translation process agency is negotiated, wherein identities are fought over, roles ascribed and power relations fixed (Tait & Jenson, 2007). The negotiation process is marked by the establishment of an OPP, which is normally an actor which becomes indispensable to the network, and acts as a gatekeeper through which all the other actors have to move. For example, for the other designers to accept their assigned roles or programme of action, the actor who managed to establish themself as OPP becomes the focal actor or spokesperson of the network (Callon, 1986c). A spokesperson in a collaborative design is an actor who speaks on behalf of the design team and works to capture other actors' attention, actively mediating goals to enrol other actors into the design network. The representation is based on the focal actor's ability to express themself. It is easy to trace the role of human spokespersons because they express themselves by speaking.

The ANT analytical framework employed depicts Web 2.0 technologies as non-human actors, which are mobilised into the network to affect various agents. Web 2.0 technology not only acted as conveyors of information but as mediators of student designers' actions and experiences. It was easy to follow Web 2.0 technology as an actor in the collaborative design process because the technology left vivid traits, which were readily available for scrutiny. I used these traits to describe its attributes and features that made the technology one of the mediating actors in the collaborative design process. When considered as a mediator, Web 2.0 technology is essentially seen as contributing something to the chain of interaction or associations created during the collaborative design process (Sayes, 2013). There are two concepts of mediation from ANT vocabulary, which I have used to understand the role of Web 2.0 technology in collaborative design, namely inscription and delegation. I use these two concepts of mediation to reflect on the extent to which we ought to view Web 2.0 as non-human actors that have equal capacity for agency in the collaborative design network.

In terms of ANT, Web 2.0 technology can play its mediation through its capacity to produce prescriptions that can be expressed in language as a script. According to ANT, a script is a series of instructions on how to act (Akrich & Latour, 1992). The traces that are left by Web 2.0 technologies on the platform can be viewed as scripts that mediate designers' actions. In other words, the concept of a script gives Web 2.0 their affordances to mediate action as material things and not as mere carriers of signs or functions. They shape the way designers carry out the design process and such influence can be deliberately inscribed into them. Thus in ANT action is delegated into a material artefact. In other words, delegation denotes that some programmes of action can be 'inscribed' into artefacts. According to Latour (1994a, p. 38) delegation is the "most important meaning of mediation" to be considered when analysing the role of technology in an actor network.

Since the mediation primarily concerns action, the part played by Web 2.0 should be interpreted as a mediation role. By the term 'action' Latour (1994a) not only refers to the conscious activities of intentional subjects, but everything that is happening – thus anything that leaves traces on reality. Therefore, during the process of tracing the mediating action of Web 2.0, my focus was on how the technology co-shaped what was happening during the collaborative design process. According to ANT Web 2.0 technology can play its mediation role by directing the way the collaborative design process is carried out. What was therefore important for analysis of the mediation role of Web 2.0 technology in collaborative design was to elucidate the particular ways in which the technology shaped the collaborative design process.

6.2.1 The mediation role of Web 2.0 technology

My analysis of the data shows that Web 2.0-facilitated design is indeed a dynamic network in which it is difficult to fix anything a priori. Both the actors who were enrolled into the network and the roles they played were not predetermined but were constructed through the ties that were formed among the actors. My analysis shows that the various Web 2.0 technologies used exercised their agencies to other actors involved in the design project, thereby shaping and modifying the relations between them (Latour, 1999b, 2002). Due to diverse perspectives that exist among the actors, the sharing of design ideas and information cannot be viewed as just a matter of the sender and the receiver. Information was shared through an interactive process that aimed to elucidate the design problem to provide direction on what action the designers

would take. Web 2.0 technologies allowed for spontaneous communication that facilitated actors to take the right action as required by the connections created among them. While a link between two actors may be said to exist, the links remain metaphysical until acted upon by interaction between them to produce tangible meaning.

The ease with which Web 2.0 allows student designers to get across their point of view gives them the power to influence the design network connectivity properties. The effortless communication essentially meant that student designers could interact with each other quickly and easily, without requiring a lot of formal or technical setup. The ability of the student designer to communicate in real time made a difference during the design process. This took place regardless of distance and time differences among the actors. Furthermore, by allowing the circulation of inscriptions and visual representation of design ideas as well as of the engagement of experts in the collaborative design network, Web 2.0 technology mediated the materiality of the associations created between them.

Web 2.0 technology did not just act as the conduit for information transmission, but mediated the translation of the interests of the actors involved through dialogue. The student designers engaged each other and shared design ideas through dialogue, as they sought to understand the design problem. Student designers did not just take all the ideas presented on the system, but were able to filter the information based on the context most relevant to them. The ability to filter based on what the student designer considered relevant or interesting was highly beneficial, as it was shown to positively affect the evolution of the design solution and the way conclusions were reached. At the same time the ability of Web 2.0 to support the documentation of conversation among the student designers ensured that they remained connected with the design activity even during the physical absence of their colleagues. For example, one spokesperson noted that the use of WhatsApp helped to keep them focused on the design project:

> *Ah, like looking at this WhatsApp we are talking about, it's, it's in terms of how we used it, the communication is immediate, we could have cases where one is here at college, one is at Glen View and another is somewhere else. We talk about someone is having some challenge there, he communicates with the others, we have a group account for that. We both, all make contributions that make that part to quickly make a decision as to what he can do to proceed while that side in our absence.* **(Source: WhatsApp message exchange)**

In addition, Web 2.0 technologies allowed for ubiquitous methods of data input through a variety of equipment, including personal computers, laptops and smart phones. This further enabled student designers to make their contributions anytime and anywhere, thus keeping the network active 24/7.

In general Web 2.0 technologies mediated the way design ideas and information were shared among the student designers. Web 2.0 technology also mediated the way the focal actors or student leaders as spokespersons (from now onwards) presented the design problem, helping the other actors to build their thoughts about the design solution. The agreed interpretation of the design problem acted as the first OPP which student designers needed to cross in order for the design process to start in earnest:

> *… then someone came up with a project a wild one, this ah why can we do this project people don't want to talk about in public but it will help them in terms of their health, so with that we thought it was joke, we consulted the lecturer about that project and he was .. about it, thus how it started and now we are in it*. (Interview with the Spokesperson for group C)

The focal actors of each group and the Web 2.0 technology were instrumental in influencing other student designers to enrol into the design network and in keeping the student designers together. These two actors exerted their agency in such a way that they established themselves as the spokespersons of the network.

Web 2.0 technology complemented efforts by the human spokespersons that employed various influential strategies which enticed other actors to join and take part in the collaborative design process. As suggested by Shiga (2007), the enrolment of other actors into the design network involved some modification of their identities and the use of a variety of means of influential activities, including persuasion.

The spokespersons employed Web 2.0 technology to work around the clock to keep the network together. However, in instances where the human spokesperson lost their voice and persuasive power, Web 2.0 technology would work to keep the network going. For example, when some actors left the network or became inactive for a long period of time, Facebook, would send updates on the conversation taking place on the forum through email. By so doing

Facebook enrolled other actors in order to keep the network together. Students had an option to read the message via email or to log on to Facebook and see all the conversation. By virtue of these messages it may be argued that Facebook '*spoke'* on behalf of the group. Hence Web 2.0 technology was able to establish itself as an indispensable actor in the collaborative design network.

In instances where Web 2.0 technology assumed the role of the spokesperson, the technology can be said to have assumed the role of shaping the way allies viewed the design task at hand. By giving student designers access to other student designers' ideas in a rich multimedia environment, Web 2.0 technology strengthened the ties between the student designers and the design problem. Web 2.0 technology strengthened network ties due the ease with which student designers were able to use it. Its user-friendliness saw every student designer being able to use the technology to share their ideas. This helped the ties among the actors in the collaborative design network. Student designers would find it difficult to participate in the collaborative design in the absence of Web 2.0 technology. For example, on several occasions student designers would blame their failing to participate on the unavailability of the Internet.

The data also show that Web 2.0 technology mediated the translation of the student designers' understanding of the design problem. This resulted in the alignment of interests among the student designers on the design solution to pursue. The agreed upon design ideas were translated into design sketches and working drawings in the design studio. These inscriptions and representation of the design solution are called intermediaries in ANT terms. These convey design ideas which were discussed and agreed upon by the student designers. Their circulation through Web 2.0 technology allowed the student designers to build some common understanding of the design problem. Furthermore, the student spokesperson employed Web 2.0 technology to distribute roles and lay out the order in which major design issues were addressed.

Intermediaries, which included sketches, diagrams and videos which were circulated through Web 2.0 technologies, helped mediate the alignment of interests among the student designers. Although inscriptions such as design sketches and working drawings have a tendency of prescribing some programme of action, their circulation in the design network through Web 2.0 made them appear more like work in progress. They were never considered as the final product; even an attempt to black box them in working drawings was not successful in making

them detect how the design artefact was created. Web 2.0 technologies made these inscriptions become leaky boxes, referred to as such because student designers were able to reflect on them and, using new knowledge gained through interaction with other student designers and the experts they engaged, were able reconsider them. More often than not their working drawings were modified, with the effect of changing the course of the collaborative design process.

Furthermore, Web 2.0 technology provided a design space for a heterogeneous set of tools (sketches, drawings, pictures and videos) to coexist. A crucial feature of Web 2.0 with regard to this aspect is the ease with which one can switch from one tool to the next. The student designers were not tied to one tool, but would move freely between different tools. Since collaborative design is a dynamic process that makes use of various tools to carry out various tasks, student designers needed to be able to switch between tools and the functionality they provide according to the demands of the given situation.

Web 2.0 technology also provided a rich medium for attaching photographs and video files that mediated student designers' illustration of their ideas. WhatsApp camera, for example, made it easy for student designers to capture and share pictures that illustrated their ideas on the design problem and its solution. In addition, the Internet bundles, for example Facebook bundles and WhatsApp bundles, ensured that student designers would capture and share pictures and videos which helped mediate the alignment of interests among them. The amount of bandwidth available through the university LAN and Wi-Fi as well as the mobile service providers enabled fast and efficient sharing of high-quality design information. High- quality presentation of ideas was critical for the designers to develop a common understanding of the design problem and its solution.

The ubiquitous nature of Web 2.0 working spaces is characterised by informal, spontaneous and unplanned interaction among the student designers that keeps them connected 24/7. The dialogue among the student designers took various forms. Although most conversations were scheduled in advance by the spokesperson, some were spontaneous and unintended. More often than not student designers found themselves in some unplanned conversation which helped to shape how the design process was constituted. Even the planned conversations ended up with student designers engaged in unplanned discussions, which led to major decisions on how the design process proceeded. From time to time student designers would call the attention of colleagues to some aspect of the design problem, at times drawing attention to something they

would have overlooked during previous discussions. Such dialogues forced the student designers to revisit certain decisions they made, with the effect of changing the course of the design process. It is such spontaneous conversation that reflects the highly contingent character

> This is what I have for the group guys say something. How is it guys? **(Facebook posting posted October 18, 2013 at 7:27pm**)
>
> Hey guyz [guys] wake up where are the pictures guys
>
> **(Facebook posting October 17, 2013 at 5:41am via mobile)**

of the collaborative design process as it unfolds. These conversations helped student designer teams to correct mistakes rapidly because of an iterative, non-sequential approach.

Furthermore, the Web 2.0 technology platform created a flat design environment in which students were free to discuss various issues as they wished. The student designers took advantage of this affordance of Web 2.0 to engage in opportunistic conversations to discuss various issues which at first sight seemed irrelevant to the design project. Such conversations were important for dealing with relevant but hidden issues affecting the relationships among the student designers. Although not directly relevant to the design task at hand, these helped strengthen the ties among the student designers and created a collegial environment conducive for design creativity. The box below shows examples of such conversations and seemingly irrelevant information shared by student designers during the design process.

> My shamwiries? [friends] Merry Christmas and happy new. (Facebook posting
>
> **K M uploaded a file.**
>
> Manchester United, Wembley Stadium, FA Cup Final, 19th May 2007 Chelsea FC Didier Drogba's Five Greatest Goals for the Blues Bleacher Report.flv
>
> Download · Upload Revision
>
> Like · · Get Notifications · October 22, 2013 at 1:44pm

However, although such conversations were largely viewed as counterproductive, the analysis shows that they also had a positive role to play. Such opportunistic conversations provided the lighter moments that student designers needed to take a break from the design task at hand, without having to go away from the task. They offered moment-to-moment opportunities for

student designers to get to know more about other students' state of mind during the course of the design process. Such conversations promoted transparency of process and progress, which established strong ties between student designers.

Previous studies have established that team mates who trust each other are more motivated to work together to produce higher-quality work (Gothelf & Seiden, 2013). The transparent dialogue helped in the alignment of interests, leading to trust and shared meaning making among student designers. It is important to note that the design process needs to be kept open to new ideas which will always be evolving to ensure that the designers are able to arrive at novel and sometimes unexpected solutions. According to Wagner, Bratteteig, Stuedahl, and Mortberg (2014, pp. 42-43)

> Openness implies that decisions about possible design trajectories are not made too quickly, and requires that the various actors involved present their ideas in a form that is open to the possibility of change.

However, if these conversations go unchecked they can be counterproductive as they have the potential to remove the focus of student designers from the design project. For example, in this study student designers who were concerned about progress would be heard making their complaints and asking colleagues to focus on the project issues.

The role of the spokesperson then becomes very critical. The spokesperson would work to bring the network back to its main objective, by reminding colleagues of their objective. By employing various tactics spokespersons were able to ensure that the design process progressed in the desired direction. For example, one student designer said:

> *I think we shld nw* [we should now] *agree on the photos we uploaded so that we come with the best wc we wl* [which we will] *use to present. Everybody effort is appreciated.* (Facebook posting)

The trajectory was, however, not linear and sequential. Unexpected trajectories were observed which led to a new way of carrying out the collaborative design process:

> *We have now decided to use a video clip and we are now shifting from the media we wanted to use of flip charts to that of a video which wl b* [will be] *portraying various types of Wood Shaving collection devices and we agreed about the initiative wc* [which] *Monalisa had come with.* (Facebook posting)

Furthermore, my analysis shows that Web 2.0 technology created an interactive design space for collaborative reflection which exposed the student designers to a diversity of thought and ideas, as well as different approaches to reflection. Web 2.0 mediated the collaborative reflection by making student experiences explicit and provided space for reflection that allowed student designers to gain a deeper understanding of the design problem as well as fostering higher-order thinking. Collaborative reflection helps designers engage more with the design process and reflect on their experience, individually and as a group. The reflection was focused on specific situations, for example during analysis of the design brief and evaluation of the design solution.

Individual students who sought help for their own reflection also initiated collaborative reflection on different aspect of the design process. Web 2.0 technology-mediated collaborative reflection process can therefore be seen as "people engaged in finding common meanings and making sense of the collective work they do" (Hoyrup, 2004, p. 457) or as "tool(s) for explicating and making implicit knowledge embedded in contexts" (Järvinen & Poikela, 2001, p. 288). There is evidence for reflection, which includes critical opinion sharing during discussions, not rushing to agree upon opinions, challenging groupthink, asking for feedback on one's own actions, and openness about mistakes during the discussions. Alignment of interests was made possible through collaborative reflection when an individual student linked his/her knowledge to the experience of others (Daudelin, 1996) or when the group combines different viewpoints stemming from its actors' experiences and collaboratively reflects on them (Hoyrup, 2004).

My analysis shows that both reflection in action and reflection on action (Schön, 1983) were present. The following statements made by two students are good examples of reflection in action:

> *Sure Joseph but please can u upload the picture on this group's wall so that we can be able to understand and criticise the idea if it needs criticism.* (Facebook posting)

> *I will also upload mine but l think of Monalisa is good cz* [because] *it has three stages hence l will download it and make some additions using PowerPoint.* (Facebook posting)

Regarding reflection on action, Web 2.0 technologies captured data that made reflection possible even some time after the experiences, diminishing memory loss or deviations in perceptions of an event.

To conclude this section, I suggest that we focus on Web 2.0 technologies as material actors mediating the evolving design process by inducing action or participation in other actors in the design process. The findings of this study demonstrate that Web 2.0 technologies were able to exert their agency as material things and not only as carriers of meaning. Hence Web technologies should not be viewed as simple tools for communication, as described in some of the literature, but as non-human actors which can mediate the collaborative design process and shape the way it is constituted. Web 2.0 technology stirred the collaborative design process by stimulating actions, thus actively contributing to the shaping of the collaborative design network.

Latour (2005), defines mediation as some kind of relation or association which implies what mediators make other actors do, and cannot always be predetermined. They can make other actors do both expected and unexpected things. When an actor enters into a relationship with another actor, the original programmes of action of both are translated into a new one. This complicates the role played by Web 2.0 technology. More often than not student designers used Web 2.0 in unforeseen ways that resulted in unforeseen influences on their actions. To demonstrate this, Web 2.0 technologies used by students would dictate when and how students would work, and what information they would share. Students would end up taking actions that they may not have planned to do. The technology used would sometimes resist their actions and thus change their plans of action. In practice, the student designer and Web 2.0 technology interaction resulted in unexpected actions. Thus, instead of assuming that agency is predictable and fully controllable, we should rather acknowledge its relational nature and that agency develops in the process of technology usage. This illuminates the ambiguities and contingencies of relationality as a resource for collaborative design (Gaver, Beaver, & Benford, 2003), which calls for the ability among designers to deal with unexpected situations that may happen during the use of technologies. Since the analysis shows that Web 2.0 technologies mediated action by motivating the student designers to act in unpredictable ways, I propose an interpretation of the Web 2.0 technologies as action stimulants which actively contributed to shaping how the collaborative design process was constituted and carried out in practice.

Since action is by stimulation, in most cases the consequences would not be clear but rather were unintended, because as the actors in the network were stimulated they reacted to the stimulus and not always in an expected way. Even when the spokesperson or an inscription had a strong programme of action, the actors were not disciplined (Latour, 1988a). The mediation role of Web 2.0 technology was assumed as a result of a shift in the type of links among the actors from "a provisionally less reliable one to a longer-lasting, more faithful one" (Latour, 1988a, p. 306). The performance of a particular role during the collaborative design process depended on the strength of the links between heterogeneous actors and their enrolment and mobilisation into a singular course of action.

This view of agency challenges both the technological and social views of agency. On the one hand the social deterministic view maintains that only humans can possess agency and largely ignores the different methods of appropriation of technology by humans (Rose & Jones, 2005). In other words, social determinism underestimates the role and impact of technology in shaping human intentions and social structures. On the other hand the technological determinism perspective gives pre-eminence to the role of technology in shaping human agency. From an ANT perspective I wish to extend our understanding of agency by proposing a relational view of agency. According to the relational view, agency is neither an attribute of subjects nor of objects. How the students were made to act during the design process was not predetermined or shaped by the technology. Rather, it was a result of "the ongoing reconfigurations of the world" (Barad, 2003, p. 811), an effect of a heterogeneous network of human and non-human actors (Latour, 2005).

A striking revelation from the analysis is that Web 2.0 technologies exerted their agency as the spokesperson for the design network. They spoke on behalf of the network. Therefore one of the major findings of this study is that the role of 'spokesperson' is not the sole preserve of the human actor. Web 2.0 technology such as Facebook can represent and speak on behalf of a network. This is an interpretation that adds to the collaborative design literature and to the definition of spokesperson in ANT.

Furthermore, Web 2.0 technology not only conveyed information for the student designers but also provided a working space for student designers to share their experiences and communicate about them. By allowing student designers to share and compare their

experiences, the technology as an actor played a mediation role during the design process. Web 2.0 technology mediated the collaborative design progresses through dialogue, and articulated and elaborated the different working ideas through which the final design artefact emerges.

Dialogue in the Web 2.0 design spaces provided a tool for the design groups to discuss and develop the requirements for the design. In the process of translating student designers' ideas into a design solution, other design requirements were further established, making Web 2.0 design working spaces particularly well suited for such a context where actions and requirements are evolving. As the conversation evolved, student designers provided each other with critical information that was necessary for the alignment of their diverse ideas, thus making them able to agree on one design solution, which they further refined to provide a satisfying design solution. The non-linear and non-sequential nature of the Web 2.0-mediated collaborative design process allowed the student designers to revisit their decisions and effect the necessary corrections to the design solution easily. In so doing, Web 2.0 thus mediated the translation of ideas into design artefacts.

6.3 Mapping the of Web 2.0 in design controversy

In this section I illuminate the design controversies that were encountered by the student designers, paying particular attention to the mediation role played by Web 2.0 technologies. I use four of Latour's (2005) conceptions of sources of uncertainty: the nature of groups, nature of actions, nature of objects and nature of facts. However, Latour (2005, p. 35) cautions us to note that these sources of uncertainty "have to be piled on top of one another, with each one making the former even more puzzling until some common sense is regained – but at the end". This is not a simple matter! In fact, with regard to design Latour (2008, p. 12), further argues that:

> Now here is the challenge: In its long history, design practice has done a marvelous job of inventing the practical skills for drawing objects, from architectural drawing, mechanic blueprints, scale models, prototyping etc. But what has always been missing from those marvelous drawings (designs in the literal sense) are an impression of the controversies and the many contradicting stake holders that are born within with these.

Therefore, to illuminate the role of Web 2.0 technology in design controversy I took Venturini's advice that when looking for controversies we should search where collective life

gets most complex. According to Venturini (2010, p. 9), the object of the cartography of controversies is found:

> where the largest and most diverse assortment of actors is involved; where alliances and opposition transform recklessly; where nothing is as simple as it seems; where everyone is shouting and quarreling; where conflicts grow harshest.

Callon (1980), also notes that these zones of controversy and uncertainty are not defined through logical deduction from the existing body of knowledge, nor are they the result of straightforward political or economic influences. Design controversies are therefore certainly a complex phenomenon to observe. Through following the traces left by the actors I was able to identify the different controversies that the designers in this study encountered during the design process. Capturing the dynamics of a controversy opens it up to informed scrutiny that leads to a better understanding of the circumstances that surround it. I mapped the actors' main statements and traced the thick mesh of relations among the statements that circulated in controversy. Certainly mapping the controversy surrounding Web 2.0-facilitated collaborative design enables us to present some new ways of visualising the dynamics of controversies ushered into the design process by the new and emerging design tools.

In this study I use the term 'controversy' in its widest sense "as a general term to describe shared uncertainty" (Macospol, 2007, p. 6). In practice controversy in collaborative design refers to a situation of disagreement among different actors involved in the design project. In other words, by design controversy I refer to "situations where actors disagree (or better, agree on their disagreement)" (Venturini, 2010, p. 10). Designers are embroiled in various controversies surrounding design, which are not simple matters of fact but complex matters of concern. Design controversies begin when actors discover that they cannot ignore each other and they end when actors manage to work out a solid compromise to live together (Venturini, 2010).

Drawing from four of Latour's (2005), five sources of uncertainty mentioned above **(see also section 5.4)** my analysis of the data revealed that Web 2.0 played a critical role in mediating controversy in the following aspects of the design process;

- Controversy over what constitute the design problem
- Controversy over what constitute a collaborative design group

- Controversy over what constitute student participation
- Controversy over what constitute the design solution

I discuss the role played by Web 2.0 technology in dealing with these controversies paying particular attention to the technology's agency mediation.

6.3.1 Role of Web 2.0 on controversy on what constitute the design problem

As regard the controversy surrounding what constitutes the design problem, the crucial thing to note is that the object of design (the design problem) should always be understood as a controversial and not as an indisputable fact (Latour, 2005). In all design projects the designers are always dealing with wicked, ill-structured, and vague constructions of reality. Such realities can therefore not possess one meaning for them to be considered as matters of fact. During the design process constructs, which need interpretation, should be constantly negotiated and exchanged. The interpretation and meaning given to them is dependent on the actors involved. Additionally, actors in a design group are bound to differ in both the ways in which they view the design problem and in how they communicate and represent the design solutions they are proposing. Web 2.0 technology would be seen as a place where this uncertainty can be dissolved through a free and open dialogue that allow student designers to express themselves in ways they prefer most.

Controversy arose from student designers' lack of the knowledge needed to understand the design problem and the development of alternative design solutions in the first place. Since design problems by their nature are wicked (Rittel & Webber, 1972) and ill-defined, both the course of action of the design process and the evolution of the design solution could not be straightforward and easily agreed upon by all actors. In fact it has been argued that no human problem solvers can identify all the possible solutions to a design problem but can only settle for choices that satisfy the problem definition at the point in time (Whelton & Ballard, 2002). Each student designer had his/her own understanding of the design problem and therefore a different way of thinking with regard to how to arrive at the solution. This was coupled with the controversy associated with the student designers' diverse knowledge of which aspects constitute a good selection. As such, a daunting task for the student designers was to come up with an agreed upon design solution from the unlimited alternatives. Web 2.0 mediated the

alignment of the ideas by making such information explicit. The student designers needed to gather and analyse the information that was required to make decisions.

A design solution presented problematic situations associated with the multiple alternatives from which to choose. Even where a preferred solution was agreed upon, it was difficult to determine with certainty how the final product would perform until a prototype solution was produced and tested in practice. While it is assumed that a thorough discussion before taking a decision on which alternative to take would reduce uncertainty at this stage, the data show otherwise. As the designers gained the required knowledge to make decisions, they used it to develop new alternatives, resulting in increased controversy and uncertainty among the student designers.

Nevertheless, this controversy on what constitutes the right solution to the design problem is not necessarily negative. Uncertainty associated with having multiple alternatives was desirable, since it encouraged the designers to explore as much of the design space as possible.

> *Its excellent wat Monalisa is suggesting and I tnk now we hv to come up wth a different design this tme using this idea.*
>
> *Great monalisa ...I think this is more intrestng even though I, Martin, Moyo and Huni tried to cme up with smthing also, but we will go by this.*
> *(W)e will meet tomorrow good people, this idea is good!!*
> *October 20, 2013 at 3:56pm · Like View 6 more comments*
> *Sure guys tomorrow, its full time business*
> *October 20, 2013 at 4:10pm via mobile · Like*

Controversy arising from this was managed by the alignment of interests through the enrolment of sufficient allies and the translation of student designers' interests so that they agree to think in a particular way and act in ways that maintain the network (Walsham & Sahay, 1999). The quotations below illustrate the usefulness of multiple ways of understanding the design problem and its solution and how Web 2.0 has helped align designers' interests.

What constitutes the correct interpretation and understanding of the design problem and its solution cannot be considered as a matter of fact but as a matter of concern. There is no one way of knowing and understanding what constitutes the design problem and its solution. As such the spokespersons in each design group guides student designers in dialogue using the Web 2.0 technology platform to help them to work upon, transform, link, merge and displace

the interests of other student designers in such a way that they consent to the spokesperson's imposition of what constitutes interpretation of the design problem and its solution.

As such controversy in Web 2.0 technology-facilitated collaborative design is not always negative and therefore undesirable. It is indeed both positive and negative. Controversy in collaborative design becomes negative when it results in inefficiencies in the design process or results in poor decision-making. For example, it was evident that if design controversy is resolved by compromise too early, it may cause designers to narrow down to a single concept too early and selection of a poor alternative. Although it is beyond the scope of this study to prove this claim, a poor choice early in the design process may turn out to be unfeasible as the process progresses, or may result in an overly poor and costly design.

6.3.2 The role of Web 2.0 in controversy over what constitute a collaborative design group

The controversy over what constitute a collaborative design group refers to the process of group formation and the identities of the actors. Actors are identified in action. When there is no action, then there is no actor and group to talk about. According to Latour (2005) groups are dynamic, they are ever changing and provisional, constantly made and dissolved. The Web 2.0-facilitated collaborative design process manifests itself as an open network formed by many actors into which many ideas and skills can flow. As has been illustrated in section 4.2, the actors involved in the collaborative process were constantly grouping and regrouping. Data show that changes to the network were triggered by the free, networked actions of the different actors who were enrolled in the network during the course of the design process. The elusive, unfolding nature of online groups made it difficult, if not impossible, for the group spokesperson to establish who constitute their group beforehand. As members began participating online, the design group developed in ways that were unexpected to them. Through the like function of Facebook for example some experts and even non design students were drawn to became members of the group or be it temporarily. Consequently, the collaborative design network could never be a pre-existent thing, but is always assembled and reassembled afresh through association. Due to lose of connectivity some student went for days without being members of the group. These would re-join the group when their connectivity was restored. It is a fluid and constantly evolving network which has no stable structure. The

seamless working space created by the Web 2.0 technology permitted a high degree of openness and flexibility in the network.

In Web 2.0-facilitated collaborative design controversy surrounds group formation due to the almost endless list of actors involved in the design process (Latour & Hermant, 2010). Controversy with respect to group formation was high at the beginning of a project, because no group existed previously. This is illustrated by the following quotation from one of the design group spokespersons:

> *Aha! They just said organise yourselves into groups of four. We then just organised ourselves according to the level of friendship.* (Group A)

Some networks were at their embryonic stage, as implied by the statement from one of the spokespersons during interviews:

> *Our group! Our group! We managed to identify each other's talents during our part one* [first year of study] *when we had collaborative groups for techno-preneurship as a subject we would see each and every one of us' strengths and weakness. So within that we managed to form a group.* (Group B)

A design group had to be assembled and this involved the spokesperson trying to impose his/her explanation of the design problem. However, not every actor agreed with the spokesperson's interpretation of the design problem. Since the spokesperson's ideas were exposed to scrutiny through the Web 2.0 technology, which kept a permanent record of the conversation, the student designers had ample time to reflect on the ideas and make their own suggestions. The debate was continuous, resulting in more controversy. However, in most cases the human spokesperson exercised some degree of power that he/she obtained through association with the lecturer and experts who they enrolled into the collaborative design network to support a particular line of argument. For example, when controversy continued with no sign of consensus or agreement by compromise, the spokesperson employed their power to impose their interpretation of the design problem to the network. The Facebook quotation below illustrates how the spokesperson exercised their power.

> Okay guys rather than arguing on which topic to venture into, I think let's compare the topics that we hve [have] on grnd [ground] and try to derive two senses from them the one which we can easily derive senses is prbly [probably] the best I think vacuum cleaner requires a lot to do.
>
> Like · · Get Notifications · October 8, 2013 at 8:40am via mobile

This resulted in some temporary stability on the network, as this allowed student designers to make some progress on the design project.

A further source of conflict was when the spokesperson needed to enrol enough actors in his/her programme of action. The enrolment and mobilisation of these actors made the design process unpredictable and unstable. Any attempt by the spokesperson to coordinate the discussions on the Web 2.0 technology platform would be interpreted as an exercise of power, which opened up the possibility of resistance.

6.3.3 Role of Web 2.0 on controversy over what constitutes student participation

In a Web 2.0 facilitated one can never be sure as to who is the actor in a given situation because the action dependence on many other agencies. First and foremost, it is important to note that human activity is not something that is transparent, but an assembly of many, in most cases surprising sources, which have to be untied for us to be able to determine who is actually acting (Latour, 2005). In other words, it is difficult to determine with certainty who is actually acting. Action cannot be a priori assigned to an actor. This is because in every action, the actor is not alone, there are some hidden forces that may cause them to carry out roles which are different from those they would have assumed at the beginning of the design process. Objects have agents too!

Both human and non-human actors contribute to each other as they carry out roles which are assigned to them by the spokesperson. Action is no longer in the full control of human actors, it is now mediated by many other actors. In the previous chapter we saw that there is an array of other nonhuman actors which are enrolled into the design process which have an influence

on the student designers' actions and entire design process. For example internet connectivity, and mobile computing devices that would give student designers access to the group discussion are some of the actors which mediated student designer' participation. As we have seen in section 4.3, there were also many unusual, behind the scenes actors were enrolled into the design network, for example skills to use technology, training offered, specialised Web 2.0 applications such as WhatsApp, Youtube, which shaped the way the collaborative design process was carried out. As Latour (2008) argues, without these other actors or mediators as they are known in ANT, the design processes would be unthinkable.

There is, however, great controversy in the literature surrounding what counts as a mediator and an intermediary, especially when we consider the extent to which mediators or intermediaries allow things to happen. For example, it may be argued that a properly functioning computer could be a mediator, because it allows individuals to do something they could not normally do (for example, sending a message to the other side of the world in a fraction of a second). In such a case a functional computer plays a role in changing the actions of the individual as well as the outcomes of an event because it *allowed* something to happen. However, in doing so it acted predictably: the message sender was aware of what he/she was doing as they did it, so the computer played no role in changing the predictable course of events. Latour acknowledges this ambiguity and takes advantage of it, when he says:

> As we will slowly discover, it is this constant uncertainty over the intimate nature of entities, are they behaving as intermediaries or as mediators? That is the source of all the other uncertainties we have decided to follow. (Latour, 2005, p. 39).

In other words, Latour is suggesting that future ANT studies should focus on the agents of non-humans actors in networks.

6.3.4 Role if Web 2.0 in controversy on what constitute the design solution

Actors in any collaborative design process are involved in a process that seeks to come up with a solution to a fluid and wicked design problem. No one is clear about the nature of the object of design at the beginning of the process. The following quotation from an interview with one spokesperson points to this issue:

> *You know what, I myself, I even sometimes doubted if we were going to come up with a cleaner, but my other guys motivated me.* (Interview with Spokesperson for Spokesperson for Group B)

At this stage the role if Web 2.0 technology goes further than providing a space for dialogue. It becomes an actor in shaping the solution to the problem. For example it transforms the inscriptions that are circulated through it in ways that provide student designers with an alternative way of making representation of the design problem and its envisioned solution. It thus assumes the role of a spokesperson which can speak on behalf of the group. Once an agreed solution is reached, Web 2.0 as the spokespersons guides the student designers to define the design problem in a way that constrain the number of possible responses from them. The dialogue that takes place on the Web 2.0 and the intermediaries which are circulated mediate the alignment of interests among the student designers by accommodating and constraining how other actors could orient themselves towards the proposed solution. By so doing Web 2.0 technology ensures that students seek for consent by other student designers to embark on the proposed design solution.

To conclude this section, it can be observed that the way in which Web 2.0-facilitated collaborative design dealt with controversies presents the design process in its most dynamic form. The analysis in this section shows that various controversies are always encountered among the actors which affect the way the collaborative design process was constituted. In Web 2.0-facilitated collaborative design controversy takes on added dimensions, since agency is distributed throughout the actors involved. Unlike in previous approaches to design research, it is no longer sufficient to search for moments of uncertainty only in conspicuous actors. Also, controversy should not only be looked for among human actors, but some taken for granted non-human actors also need to be followed in order to illuminate the plurality of conflicting items. According to Venturini (2010), controversies involve all kinds of actors, not only human beings and human groups, but also technology and other non-human systems. Therefore to understand controversies in the Web 2.0-facilitated collaborative design process, the heterogeneous assemblage of actors should not be taken for granted.

I have also demonstrated that Web 2.0 technologies played a critical role in dealing with controversy during the design process by enabling brief interactions, provisional ties, and reversible transformations to become more durable and seemingly irreversible. The traces left by actors on Web 2.0 design spaces illuminated controversy encounters during collaboration that would otherwise be ignored in previous design studies due to their subtle nature. Controversies emerge when things and ideas that were taken for granted start to be questioned

and discussed. This becomes an issue, especially in the Web 2.0-facilitated collaborative design process, which takes place in constantly evolving networks in which it is difficult to draw conclusions about who is actually acting. However, my analysis shows that Web 2.0 technologies provide insights into how these may be dealt with to keep the design network stable, even momentarily.

It is crucial that designers manage the controversies that arise during the process in order to improve productivity. Managing design controversy does not necessarily mean providing answers to conflict; instead, it means constructively dealing with disagreements and uncertainty to allow heterogeneous design actors to engage in alignment of their conflicting aspects of design process.

6.4 Summary

In this chapter I investigated the collaborative design process, putting a particular focus on the mediation role of Web 2.0 technologies. My analysis shows that Web 2.0 technologies restructured the way in which collaborative design was constituted and carried out in practice. The enrolment of Web 2.0 technology is at the heart of the shifting dynamics in collaborative design, where various actors (technology, designers, Internet connectivity, mobile computing devices and other actors) are creating a connective design space for communication and information sharing and design collaboration space. In order to comprehend this inter-wovenness, I employed ANT to explore how Web 2.0 platforms could be analysed as one of the conspicuous actors in the collaborative design process. ANT as a theoretical framework has the potential to give us a fuller understanding of how Web 2.0 facilitates collaborative design.

To summarise the key issues raised in this chapter, it is noted that when used in collaborative design Web 2.0 technologies are not simple tools for sharing information, as described in the previous literature; they are rather actors mediating the process. Instead of looking at them as passive transmitters of information by humans, an ANT analysis allows for their treatment as objects that actively participate in the assembly of the practices that constitute the collaborative design process. As such, the role played Web 2.0 technology is much more fragile and uncertain than portrayed in literature that prematurely black-boxes the evolving dynamics that they bring to the collaborative design process (Barab, Schatz, & Scheckler, 2004; Latour, 1987b).

The role of Web 2.0 technologies in collaborative design is not simply defined by their technical structure (Barab et al., 2004), but may be better described by the associations they create among actors in the collaborative design process. The technology took charge of the translation process by stimulating the actions that defined the way in which collaborative design was constituted. Web 2.0 technologies managed the translation process mediating the actions that acted to make the design process transparent. Its affordances helped the actors to align, enrol, and negotiate their interests.

Furthermore, the chapter has demonstrated that the Web 2.0-facilitated collaborative design process presents new forms of design controversy and uncertainties that need to be taken into account in order to reach successful design outcomes. In practice, the Web 2.0 collaborative design process is a range of actions made to solve controversies and efforts to keep the actors enrolled in the network and interested (Gasparin, 2014a, 2014b). This observation upholds ANT theorists' assertion that the process of building an actor network is a process of overcoming the resistance of all sorts of actors and weaving them into networks with other actors (Law, 1992). Although the controversies never reached the intensity of open fights, the construction of a shared universe is often accompanied by the clash of conflicting worlds. Conflicts arise in an actor network when more than one actor/s attempt to establish themselves as a point of passage. In this chapter I have demonstrated that such controversy can be dealt with when there are strong connections between the actors involved in the design process.

Web 2.0 technology helped mediate controversy among student designers based on numerous relations that were created among the actors; the cost of challenging the network was heavy on the actors who decided to differ. In other words, the technologies work to black-box the collaborative design so that it acts as an entity. This had a net effect of making the network less fragile and more stable. When the actors' actions resulted in friction, the spokesperson employed various techniques with Web 2.0 technology as mediators to resolve the controversies. Web 2.0 technology helped student designers to manage the struggles and keep the actors attached to the network. The technology facilitated the circulation of inscriptions which delegated some functions to the non-human actors to successfully enrol humans into their programme of action.

From a methodological point of view I observed that Web 2.0 introduced some new sources of uncertainty, which brought with them new forms of controversy among student designers as

they worked on the design problem. The affordances of Web 2.0 have enabled collaborative efforts that improve the characterisation of uncertainty in design (Anderson et al., 2011). Although some researchers, for example Marres and Moats (2015, p. 2) have argued that controversy in Web 2.0 platforms "may appear flippant and slight, engines of hype, attention-seeking and self-promotion (…) and therefore not worthy of serious scrutiny by those who put substantive issues first", I have found their illumination in collaborative design to be a critical factor in understanding the role of Web 2.0 technology in shaping the collaborative design process. The new settings of digital and social media (Web 2.0) practice open up important opportunities for us to understand the messy intersections of science, technology, human social and professional life (Marres & Moats, 2015).

In the next chapter I attempt some theorisation of the results of the analysis. I use the ANT resources assembled in the literature review to reflect upon the findings and to map the contribution of this study to the body of knowledge on collaborative design.

CHAPTER 7

UNDERSTANDING COLLABORATIVE DESIGN AS AN EMERGENT EFFECT

"If what is assembled is not first opened up, de-fragmented and inspected, it cannot be reassembled again"
(Latour, 2005, p. 250)

7.1 Introduction

The purpose of this chapter is to introduce ANT as an emerging perspective for understanding the Web 2.0-facilitated collaborative design process. After an initial extensive literature review to examine various ways of understanding and visualising the dynamics of the collaborative design process, I identified a significant gap in the ability to explore Web 2.0-facilitated collaborative design. This chapter illustrates how I used ANT to uncover specific themes that explain the dynamic nature of the Web 2.0 technology-facilitated collaborative design process.

I constructed the chapter with the intention of disintegrating the black box of the collaborative engineering design process using selected ANT concepts to reconstruct our understanding and the theorisation of the process at three levels: theoretical, contextual, and methodological. I drew up the themes based on a cross-nodal analysis and the heads of arguments presented in the literature review to reflect on the findings of the study from an ANT perspective, in order to assemble a new perspective that could improve our understanding of Web 2.0-facilitated design. My aim was to engage in a dialogue with the findings and ANT resources, looking for empirical grounds to theorise the nature of Web 2.0- facilitated collaborative design, paying particular attention to the mediation role of Web 2.0 technology during the design process.

The writing process was a translation in the field of design literature, the findings of the study and the reflections that I had with my co-supervisors. My intention was to be an actor in the negotiation process as I make my contributions to the field. I constructed the chapter as a process of dialogue and negotiation with literature from various sources, including journal articles, conference papers, and the findings I assembled from analysis of the data I collected in the study. I traced the heads of arguments, weaving through aspects they have added to the

available literature on collaborative design, so as to render more durable the constantly shifting meaning of collaborative design as a result of the entrance of new actors in the process.

This study has established that the collaborative design process is complex in the sense that the process exhibits emergent properties. It is clear from the findings of this study that although the engineering design is often presented as a linear, staged process, the realities and experiences of the real design process, as demonstrated in this study, are much more complex and contingent, which can best be described as an emergent process. This is because at the beginning of the process it is not possible for the designers to have complete knowledge of how the process is going to proceed or of all the information that might be needed to accomplish the process. For the same reasons, it is also not possible to predict during the course of the design process what shape the design solution or the process itself will take, since these depend on the prevailing circumstances and the relationships that will be established among the actors involved. My analysis shows that collaborative design is a messy, muddled and contingent process. It is a translation process, during which a hodgepodge of decisions that cannot wait are taken in a complex, dynamic, fluid and constantly changing environment where actions cannot be planned or predicted in any mechanical way (Akrich et al., 2002).

In the following sections I draw our attention to the theorisation of the results of the analysis as well as mobilising them to contribute to the previous understanding of the collaborative design process at three levels, namely theoretical, contextual, and methodological. I examine how the findings trace back to the literature while explaining how they contribute towards the emerging perspective of collaborative design. I use ANT as my theoretical foundation for the theorisations, based on the analysis I conducted in the previous chapters.

7.2 Web 2.0 facilitated design as an emergent process

Drawing from the analysis presented in the previous chapters (Chapters 4, 5 and 6), I propose a new perspective on the collaborative design process that is collaborative design as an emergent process. Unlike the previous design perspectives, Web 2.0-facilitated design process does not take place within a fixed structure. The findings of this study have demonstrated that Web 2.0-facilitated collaborative design does not move along a linear line from a problem to its solution. The process involves a diffuse dialogical process that is more than that implied in the rational problem-solving approach. The process moves back and forth between different

purviews as the design problem and solution co-evolve and are both continuously up for revision (Downey, 2005). The point is that a design problem is rarely completely stable in its definition once the design process takes off. As Lawson (1983, p. 86) puts it: "we should not expect a comprehensive and static formulation of design problems but rather they should be seen as in dynamic tension with design solutions". Web 2.0 technology mediated the exploration of the design problem through different solutions as suggested by Marples (1961, p. 64), who points out that "The nature of the problem can only be found by examining it through proposed solutions". As the students analysed the design ideas and contributions made by their colleagues on the Web 2.0 platform, the design situation would *'talk back'*, as Schön (1983) phrased it.

Web 2.0-facilit*a*ted collaborative design is an emergent network created as a result of the alignment of designers' interests through a process of problematisation, interessement, enrolment and mobilisation (Callon, 1986b). Various interpretations of the design problem are translated into technical solutions and procedures to be followed in search of a satisfying design solution. The process of achieving agreement (or a stable network) is dependent on the translations that take place among the actors involved in the process. Aanestad's (2003, p. 7) explanation of Latour's concept of translation is more apt for our understanding of collaborative design:

> (...) ANT claims that the actors in the actor-network theory have different and possibly incompatible interests, and that stability (or order, agreement, success, goal achievement) is obtained when the network is aligned. The alignment of the networks occurs through a process where actors' interests are translated (i.e. reformulated, modified, or changed) into more generally agreeable expressions, so that several actors may support the resulting translation

Translation, according to this definition, involves associating heterogeneous actors to form an actor network through assigning to each, "an identity, interests, a role to play, a course of action to follow, and projects to carry out" (Callon, 1986a, p. 24). This process is led by a translator who becomes the spokesperson of the actors. The spokesperson interprets or expresses other actors' "desires, their secret thoughts, their interests, their mechanisms of operation" (Callon, 1986a, p. 25). The roles played by the actors "are not fixed and pre-established" (Callon et al., 1986, p. xvi). My analysis affirms that the collaborative design process is indeed a translation process. It is a process in which the actors' divergent interests and interpretations of the design

problem needed to be aligned to each other in order for them to reach consensus on the possible solution to the design problem.

For this study, the problematisation took place in the Web 2.0 design space. Student designers first needed to agree on the Web 2.0 technology to use. Their selection of the technology to use was mediated by the skills and ICT training that the students had received. The Web 2.0 platform selected became one of the OPPs which, once accepted by the student designers and supported by their IT skills and the Internet bandwidth among other things, they would not do without. Thus the Web 2.0 technology made itself indispensable, due to its ubiquity and ease of use.

The focal actor, who by default became the spokesperson of the group, worked to "interess" and enrol other actors, such as fellow students, experts, mobile phones and mobile Internet connectivity, and in some cases users, into the collaborative design process. The students who were novice users of the Internet and Web 2.0 technologies were translated into competent users of the technology. This translation further increased the ties among the design actors and resulted in a stable network of actors with aligned interests. The second moment, "interessement", involves "one entity attracting a second by coming between that entity and a third" (Callon et al., 1986, p. xvii). To 'interess' other actors the spokesperson forged privileged relationships that formed a system of alliances between other student designers. The spokesperson managed to forge these associations by convincing other student designers to accept their definition of the exclusive identities and desires. This was mainly achieved through seduction or a simple solicitation, but when the student designers took longer to reach consensus on some controversy, the spokesperson used the power derived from the types of association among actors if necessary to exert 'pure or simple force' to interest them. This was done to "corner the entities to be enrolled" (Callon, 1986a, p. 209) in preparation for their enrolment into the design network.

For a Web 2.0-facilitated collaborative design process to be successful, the actors in a network should accept the roles, a worldview, rules of acting and the path to follow as the network emerges. Enrolment entails student designers putting into action the roles defined for them by the spokesperson during the problematisation phase. At this point, to make the design translation a success the spokesperson needed the cooperation of the other student designers and non-human actors including uninterrupted Internet connectivity and computers which

would enact the roles assigned to them. The circulation of intermediaries such as design sketches and working drawings helped ease the actors' enactment of their roles. Furthermore, Web 2.0 technology enabled a series of "multilateral negotiations, trials of strength and tricks" (Callon, 1986a, p. 211) to persuade other student designers to play their part in the collaborative design process.

Finally, through mobilisation the spokespersons worked to convince the other student designers to enact the agreed roles. At every moment the student designers were seduced or forced to follow the programme thus laid out for them. As such the actors and intermediaries experienced some displacement or some literal movement that was necessary to "solidify" the collaborative design actor-network and thus render the translation successful (Callon, 1986a, p. 28). Thus, a stable actor network is mobilised for the production of the prototype, whereupon new actor relations would be formed and a new design actor network would emerge.

Inscriptions, especially in textual form, were central in the translation process, because they carried meaning to other designers, thereby making action possible. Inscriptions are the results of placing one's interests in material form. These define how humans and non-humans are interconnected in a heterogeneous network. They shape and constitute the actors' interactions and therefore influence the actors' performance. In this study multimedia inscriptions, including text and video, circulated via Web 2.0 technology presented designed ideas in such a way that their meaning and significance were irrefutable. Presented in this way, the inscriptions not only helped leverage credibility of student designers' ideas but also stabilised networks (Law, 1992; Van-House, 2003).

Web 2.0 technology as an emergent process developed in two different directions, that is, towards convergence and towards divergence of its actors, as illustrated in Figure 15.

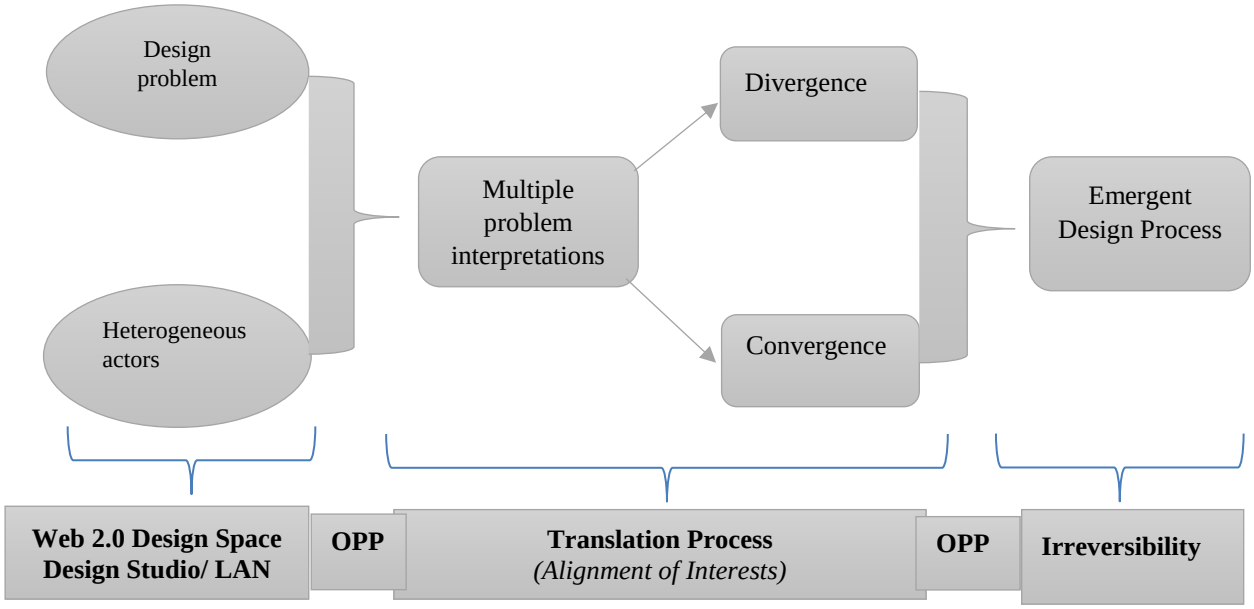

Figure 15: The emergent effect of Web 2.0 facilitated collaborative design process

Convergence and divergence imply that a collaborative design network can either move towards stabilising itself or towards disintegration, when it becomes easy to reverse the connections among the actors. The more that heterogeneous elements found in an actor network are aligned, the more stable and predictable it becomes. However, divergent ideas are not necessarily negative, but help the designers to consider both sides of the design problem. Once divergent interests are aligned, it becomes difficult to untie the connections created during the translation process. The design idea or design solution agreed upon becomes an OPP which once crossed reaches a point of irreversibility. The solution is inscribed into some working drawings which, according to ANT, become one of the intermediaries that are circulated in the collaborative design process. The working drawings have inscribed in them a particular action expected from the designers. Another observation (which is, however, beyond this study) is the assumption that once the translation process reaches the alignment of interests a more satisfying design solution is most likely to be achieved. However, evidence of this assumption is not given in this study because it did not involve analysis of the design solution.

Web 2.0 technologies provided a new dimension of design translation, which allowed designers to work iteratively, making them ready to go back and reframe the problem repeatedly as the design unfolds. Web 2.0 technologies facilitated the thorough discussion and negotiation among the actors which resulted in the agreed interpretation and possible solution acting as

OPPs, which resulted in stable networks being formed. As consensus among actors about the possible solution to the design problem emerged, "the 'pluralism of artifacts' [design solution] decreases" (Fallan, 2008b, p. 86). Stability in an actor network was achieved when there was some convergence of ideas among the actors. Any collaborative design network is essentially stable as long as there is convergence of thinking on the design problem and the possible solution. According to Callon (1991), convergence entails maintenance of some degree of accordance, which is engendered by a series of interpretations through the circulation of intermediaries as well as the maintenance of the frontiers of the resultant network. In this case, once a solution was agreed upon the student designers worked hard to come up with working drawings which would be used to create the design solution in the engineering workshop. The working drawings became the new OPP and the embedded relations remained stable as long as the actors remained the same.

The more convergent the ideas of the actors in a network, the more the network is aligned and coordinated. In such a network the actors are more willing to meet and move towards the same target. In a convergent collaborative design network, actors have the possibility of mobilising all the competences and necessary resources, which ensures them the collection of an individual force. However, convergence in a collaborative design network does not mean that all the elements act or become the same, it "simply means that any one actor's activity fits easily with those of the other actors, despite their heterogeneity" (Callon, 1992, p. 87). Where there are divergent ideas about the design problem, some degree of stability or temporary stability is needed for the collaborative design network to achieve its goals. This is achieved through the translation process, where the different actors' interests are aligned. The resultant network is more successful because it will be difficult to undo the ties that were created by the long chains of translation among the actors. In any case, it is in the interest of all actors within the collaborative design process to stabilise the network in order to guarantee the achievement of their goals. As suggested by ANT, the stability of a collaborative design network depends on the "impossibility it creates of returning to a situation in which it was only one possible option among others" (Callon, 1992, p. 89). The collaborative design network thrived for stabilisation because it was in the best interests of the student designers.

However, the lithe and dynamic nature of the Web 2.0-facilitated collaborative design process is demonstrated by my observation that the 'black-boxed' design process was reopened on several occasions, for example when a new actor is enrolled into the network or left the

network. During the process of mutual shaping between the new actor and the existing network, which would have become an actor in its own right, massive adjustment on the part of either the network or the joining actor resulted in a completely new direction in the collaborative design process. This upholds Latour's assertion that networks emerge and are shaped by aligning more and more actors. It should be noted that the continual growth of the networks may allow changes that are detrimental and lead to destabilisation of the network. The process of translating the interests of the new actor to conform to the established actor network or the spokesperson is initially difficult, because the new actor is added into a network that would have already established its OPP. One example of this is in situations when university Internet connectivity was lost. Although the student designers shifted with ease to mobile network Internet connectivity, the sizes of files that they could upload was limited and sometimes they failed to share their ideas in their most preferred format. For example, videos would not download due to the poor download speed provided by the mobile network providers in some places.

Viewing collaborative design as an emergent process is different from the positivist view of engineering design which presents the process as something that is accomplished through a stage-gate system, with major decisions being made on the information received at each of the stages. The common perception of design as process is that it consists of a series of distinct steps which are undertaken in a "predictable and identifiable logical order" (Lawson, 2006, p. 33) to achieve desired outcomes. If applied to Web 2.0-facilitated collaborative design, such a view undermines the process of enrolling other actors, including both human and non-human actors (instruments, analysing, prototyping, interpreting the inscriptions) as well as the time and the effort spent observing how the actors are interacting with the design and the trials with the machines and the materials (Latour, 1987b).

The positivist view of design was first challenged in the 1970s by the pioneers of the design-methods movement themselves, when they recognised that the rational and scientific approach to designing overlooks the lively things about designing. For example, Jones (1977), cited in Cross (2006, p. 120) says: "In the 1970's, I reacted against design methods. I disliked the machine language, the behaviourism, the continual attempt to fix the whole of life into a logical framework". In Schön's view, such a technical-rationality approach fails to resolve the dilemma of rigour versus relevance confronting professionals. Schön's argument is that professional practice is complex, unpredictable and messy (Schön, 1983). By this Schön is

suggesting that design is not a linear process in practice, but one that is confronted with uncertainty, uniqueness and conflict. For him, designers are reflective practitioners and designing is a reflective conversation with a given situation. Both his concepts of reflection in action and reflection on action are dynamic activities which allow designers to revise, modify and refine their expertise in an unstructured manner. In order to cope, professionals have to be able to do more than follow set procedures.

Taking this debate further, Rittel and Webber (1972) argue against the idealistic and reductionistic conception of design as an optimisation process. Instead, they perceive design and planning as a practice to tackle wicked situations. Since each wicked problem is essentially unique, tackling wicked problems implies that each design solution is a unique, one-shot operation which consequently leaves traces that cannot be undone. This means that a particular wicked problem inscribes in itself a necessity for particular action. Such problems can be neither completely rational nor completely solved by traditional methods. Therefore there cannot be one predetermined procedure to be followed in solving design problems. As has been demonstrated in this study, Web 2.0-facilitated collaborative design is consequential; it is a result of the associations created among both the human and non-human actors involved in the process.

Furthermore, considering design as an emergent process and examining it from ANT's post-humanist perspective (Latour, 2005; Orlikowski, 2007) extends Schon's view of design as a reflective action. Schön (1983) has mainly considered an individual perspective of reflection, disregarding the possibility that reflection can happen among several people (Cressey, Boud, & Docherty, 2006; Hoyrup, 2004), as it happens in Web 2.0 design working spaces where a group of designers can reflect on its practice. During the design process student designers commented on each other's design ideas and design information. They also searched for and provided new information concerning design context or design elements. While it was evident that student designers were involved in individual reflection while writing down experiences and making personal comments on their own contributions, other students left comments and insights from reflection on experiences too. Furthermore, the Web 2.0 design space provided a working space that consists of design ideas, comments, new information, and meta-comments after reflections.

7.3Role of Web 2.0 in creating a new design context

A design context is described by the set of factors influencing the product being designed and the design process at a certain moment. The design process I have described up to now is based on the existence of a diffuse resourcefulness and complex design activities, which if appropriately stimulated and directed could evolve towards the scenario of the multi-faceted design context. First and foremost, ANT, which I have used to guide how I conducted this study, compels us to see collaborative design as a network process that is constituted by heterogeneous actors, both human and non-human. Hence, an ANT conception of collaborative design must capture the networks of interactions among human and non-human actors that both define and are defined by each other's agency. This means we must understand the 'designerliness' of design objects, networks and artefacts, instead of trying to provide a stand-in explanation of the design process with respect to its psychological explanation of the creative energies of the individual designers. The description should capture the socio-technical dynamics that illuminate actor relationships and define the actors and the networks that emerge from the ties created among the actors. In practical terms, I have observed that design contexts that facilitate collaborative design attitudes have definite common characteristics, that is: they have to give the actors access to appropriate technologies that promote the diffusion of knowledge, skills and abilities, as well as enhancing social and political tolerance.

My thesis in this respect is that Web 2.0 technology supported the creation of a design context in which student designers were able to meet and share design ideas, which is key to the development of a stable design actor network. Whereas most collaborative tools focus on the communication aspect, that is, the messaging function (Yesilbas & Lombard, 2004), Web 2.0 technology provided a collaborative place for the creation of the design network and design artefact itself. In this new environment of diffuse resourcefulness, designers have to learn how they can actively and positively participate in a socio-technical environment where new and, hopefully, promising ideas are emerging. It is therefore impossible to understand how the design process works without appreciating how Web 2.0 technology shapes, conditions, facilitates and makes possible everyday sociality that constitutes the design process. By this I do not, however, suggest that the 'social' is a separate field or even a context in which design could be framed. Rather, 'the social' context that is evident in Web 2.0-facilitated collaborative design should be viewed as something that is glued together by many other types of connectors (Latour, 2005), including design. Neither do I suggest that technology is a context in which the

design process takes place. When viewed as a type of connector, not as a separate, cold domain of material relations, the investigation of Web 2.0 technology should be able to shed light on the other types of non-social ties that are brought together to make the collaborative design process durable.

Drawing on ANT's assumption that an object with its scripts and incorporated programmes of action compel and rearticulate new social ties, I argue that the design context created by Web 2.0 technology can trigger specific ways of enacting the design process. In this regard, my study has demonstrated that as a type of actor network, Web 2.0-facilitated collaborative design is not an isolated and rigid purview of material relations. The parliament of things that constitutes the Web 2.0 technologies promoted the development of strong ties among the actors, both human and non-human, to stimulate and keep alive the network contexts that are the design process (Manzini, 2007). My analysis of data demonstrates that Web 2.0 technology provided student designers with access to virtual spaces where they could communicate, share design ideas, help each other and collaboratively develop a common understanding of the design process (Manzini, 2007). For example, the analysis shows that Web 2.0-based technology was used as a platform to extend the reflective conversation among designers working on a design project. Web 2.0-based technology was used to facilitate both the reflective thinking in action and reflection on action among designers through its various communicative modes and styles, including text, graphics and video.

Consequently, the focus of design research should be on conceiving how these new design contexts could be utilised to enhance the collaborative design process. In my view, what design research should do is to help to introduce a new way of looking at collaborative design which can embrace Web 2.0 technology as a key actor in the process. In the next section I address this issue in detail.

7.4A reflection of the use of ANT

One of the contributions of this study pertains to the design research methodology. Since in section 7.2 above I have proposed a shift towards an ANT of design, in this section I set a new research agenda for design studies. When considering design through the lens of the ANT framework we are not just looking at the designer and the design problem, but opening it up to other actors, hence making it more transparent. Researchers employing this approach to inquire

on the design process need to concentrate on illuminating the network formation process as well as investigating the human and non-human alliances and their networking effect (Tatnall, 2009). The interactions and associations formed among the actors and the resulting network are the most important issues. The actors are seen simply as the sum of their interactions with other actors and networks (Tatnall, 2009). As Yaneva (2009, p. 282) suggests, "An ANT approach to design would consist in investigating the culture and the practices of designers rather than their theories and their ideologies [...]". Thus researchers should concentrate on elucidating the negotiations that result in the networks which are enacted and configured through the actions of both human and non-human allies. My thesis in this regard is that expanding the network vocabulary of ANT to the field of design research should mobilise this method's persistent ambition to account for and understand (not to replace) the objects of design, its institutions and different cultures.

For example, in conducting this study I was guided by ANT's post-human ontology, where I looked at all things in the Web 2.0-facilitated collaborative design as made equally of human and non-human influences; and its epistemology, where I sought to describe how the intertwined relations between human and non-human elements constituted the collaborative design process. My methodological approach to data collection was to follow the actors, stopping to collect the traces that they left and sitting down to write rich descriptions that show the fluid associations among things, as well as revealing what gave the actors the energy necessary to act. However, this was not a simple matter, because it entailed dealing with complicated entanglement, since Web 2.0-facilitated collaborative deign is a messy process that is constituted by heterogeneous actors. Nevertheless, it is ANT's business to provide an account of such a dynamic process in which messy relationships among actors are forged, negotiated and maintained.

ANT allowed me to explore the Web 2.0-facilitated collaborative design process as a network creation process from a 'flat' ontological basis in which there is symmetry between human and non-human actors. As we have established in the literature review, ANT does not give any a priori power or complexity to actors, but such reality is built on the relations and is understood by following the connections between actors. ANT's 'flat' ontology represents networks as non-hierarchical, self-organising, collaborative, and flexible with a topological spatiality (Latour, 2005). Latour (2005)'s 'flat ontology' neither looks up to a macro-scale for explanations, nor down to a micro-scale, but rather looks across the network of material

relationships to explain the phenomena it finds. ANT argues that the idea of a 'context' or a global point of view assumes a coherence and smoothness that belies the translation and negotiation of "small, sensuous, specific, heterogeneous, non-coherent" (Callon, 1986a, p. 13) networks that make up things in the world. However, as Aanestad (2003) notes, Latour's adoption of a 'flat ontology' does not mean that hierarchies and scales do not exist. It rather means simply that if you wish to go from one site to another, then you have to pay the full cost of relation, connection, displacement, and information (Aanestad, 2003). The metaphor of a flatland was simply a way for ANT observers to clearly distinguish their job from the labour of those they follow around (Latour, 2005, p. 220).

The foregoing discussion shows that designing is not a dry or cold domain of material relations; its investigation should shed light on other types of non-social ties that are brought together to make the process durable. Extending ANT to the field of design requires us to mobilise this approach's insistent ambition to account for and understand the objects of design, its institutions and different cultures (Yaneva, 2012). This means that design researchers should concentrate on understating the design process in action, its networks and artefacts, instead of trying to provide a social, psychological, historical or other explanation of design (Yaneva, 2009). In other words, an ANT approach to design should comprise an investigation of the culture and practices of designers rather than their theories and ideologies. This implies following what the designers are doing in their daily actions as they engage in designing. Thus, for us to understand the constitution of the design process in complex environments such as Web 2.0 platforms, we should not limit our analysis to the discourses of designers. Dealing with the discourses of designers in isolation misleadingly separates the social and the technical dimensions of engineering design. In so doing, we fail to embrace the diversity of the design process (Yaneva, 2009).

ANT-inspired methodology to study collaborative design should be able to capture the movements of designers in the entire design space, from the design studio to all the other nodes, including the VDS of Web 2.0 platforms. The research methods employed should enable the inquirer to follow the designers and other actors' practices and account for their actions and transactions throughout the entire design context. Data collection through static means such as questionnaires obscure the dynamics of the collaborative design process, hence in this research I traced the trajectory of the design process as the actors engaged each other and the design problem, noting the specifics, pathways, actors and actions that constituted the collaborative

design process. Considering Latour's imperative to *"follow the actors!"* has the advantage of allowing for multiple vantage points: it can make it possible to study a situation from many angles rather than from the perspective of one or a few privileged actors. We study science in action and not ready- made science or technology. To do so we either arrive before the fact or machine or black box or we follow the controversies that reopen them. This will enable the researcher to study not only the materialisation of successive actions performed by the designers on a daily basis, but also the foreseen and unforeseen effects they might trigger. Through following what designers do, how they engage with objects and technologies, how they grab and use them, and how they attribute meaning to their actions, we can understand design as a process of enacting the social (Yaneva, 2009). Latour (2008, p. 13), argues that recognising things as acts of design opens them up, and that we need "tools that capture what have always been the hidden practices of modernist innovations" and "means for drawing things together — gods, non-humans and mortals included".

To observe the emergence, formation and growth of a collaborative design network, it was important that I traced the trajectory defined by the intermediaries that were put into circulation, who puts them there, where they appeared, what they did, as well as how they were translated and put into further circulation in the collaborative design network. However, Latour (2005) regrets ANT's use of the network metaphor in describing a dynamic process such as Web 2.0-facilitated collaborative design because it tends to suggest stability rather than fluidity. However, he has clarified that, in ANT terms the network is a method not a thing 'out there' to be discovered (Latour, 2005). In the same vein Callon (1989, p. 93) clarifies that:

> (…) the actor network should not ... be confused with a network linking in some predictable fashion elements that are perfectly well defined and stable, for the entities it is composed of, whether natural or social, could at any moment redefine their identity and mutual relationship.

Hence the nodes from which data can be collected can never be fixed or predetermined. Just as the design process emerges from the translations that take place among the actors involved in the design process, the nodes for data collection also emerged as I was following the actors in action. Through following actors as required by ANT I was able to discover the Web 2.0 design place as one where rich data could be collected. This was a dynamic environment which was made available through the university LAN and the private mobile network operators. I was able to collect rich data in text, graphic, audio and video formats. Figure 7.2: shows the emergence of the Web 2.0 node.

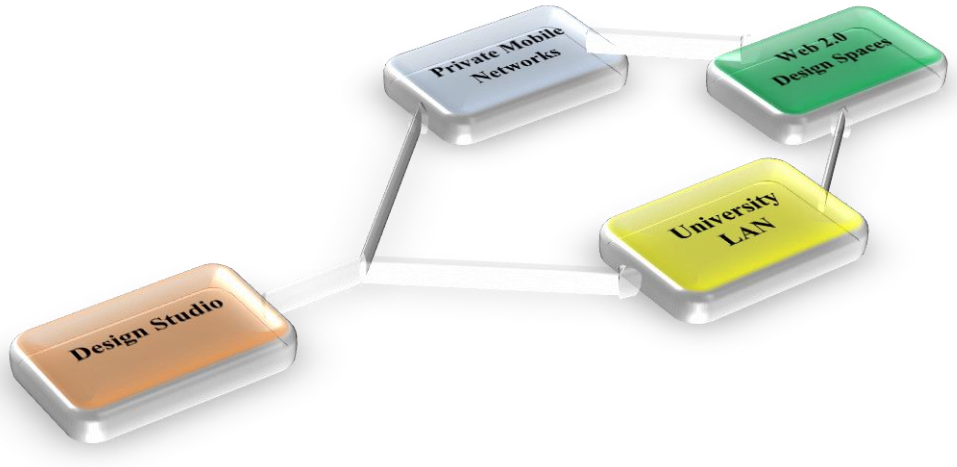

Figure 7.2: The emergent effect of the Web 2.0 design space

This is consistent with my conclusion from literature view that the design context in Web 2.0-facilitated collaborative design should be viewed as something that is fluid and ever changing. Design researchers should therefore employ a cohort of methods that will allow them flexibility to collect relevant data from both the usual data source as well as from the emergent data source. The use of ANT as my methodological framework facilitated a data collection set that helped me to capture the necessary trails left by the designers as they traversed from one node to the other during the collaborative design process.

The ANT toolkit gave me the edge in following the painstaking ways in which actors deal with the controversies which arise in a Web 2.0-facilitated collaborative design process. The strategy of data collection was to follow the actors when looking for controversy among actors (both human and non-human), and also to follow actors in their competing attempts to define the controversy (Latour, 1987b). This meant not pre-empting the boundaries of the controversies, limiting the settings that controversy takes place in, or what sorts of actors, resources and technologies were consequential for its potential settlement (Marres & Moats, 2015). Such an empiricist approach obliges the researcher to pay attention to the role of mediations and translations in the controversy. Design controversy in Web 2.0-facilitated collaborative design should be mapped by considering how the empirical object of analysis is mediated by the intermediaries and inscriptions circulated as well as the various forms of representations and the role played by the spokesperson in shaping the controversy (Latour, 2005).

Data collected through these ANT methodological exploits unlocked new sources and forms of data that are required to map the nature of controversy in collaborative design. Furthermore, Web 2.0 technology proved to be a significant actor in the illumination of design controversy insofar as it made available far more structured data than could be captured by observation methods, as is common in most ethnographic studies. Platforms such as Facebook and Twitter, for example, have significantly broadened the "grammar of action" (Rieder, 2013) by providing not just links and addresses (URLs), but also shares, mentions, likes, followers and tags among the many traces that researchers can follow. These inform-actional formats (Marres & Moats, 2015) organise activities online while simultaneously making them available for analysis (Thielmann, 2012). As such Web 2.0 technologies significantly boost the empirical and analytical capacities of digital settings for controversy analysis.

7.5 Conclusions and implications of the study

In conclusion, this study has established that the Web 2.0 collaborative design process is a messy, muddled and contingent process, which can best be described as an emergent process. As an emergent process, the path that it takes cannot be predetermined, but emerges from the network of relations that are created by the actors as they work together to achieve their commonly agreed design goals. Nothing is fixed since the actions that actors take are as a result of some negotiations with allies that are involved in the design process. It is not possible to predict at the beginning of the design process what path the process will take, since this depends on the prevailing circumstances and the relationships that will be established among the actors involved.

Web 2.0 collaborative design has the following characteristics:

1. **Emergent**: Relevant actions emerge and the solution and the problem develop together.
2. **Heterogeneous assemblage**: Constituted by both human and non-human actors, Web 2.0 technologies have agency too! They play a role key in influencing how student designers act, thereby shaping the way that the design process is carried out.
3. **Dialogical:** Web 2.0 technology is a node at which design controversy and actors' interests are aligned in a translation process.

4. **Reflective:** The intermediaries circulated on the Web 2.0 platform allow for collaborative reflection among the student designers.
5. **Risky:** There is a real danger of unending debates and dialogue without alignment of interests.

The emergent character of Web 2.0-facilitated collaborative design allows for important lessons in the development of effective methods of teaching engineering design. It can be argued that when the design process is characterised as a hodgepodge of decisions, or in Latour's terms '*designing from everywhere'*, it is no longer methods alone that produce results, but the reassemblage of the totality of translation that takes place among the actors into a stable network of relationships. In other words, collaborative design is no longer a process performed by drawing representations of the world but by drawing things together in the world. Therefore, the focus of design education should be on making the emerging assemblage of people and things work. In a heterogeneous assemblage where there are some translations of interests among the actors, the most important thing to remember is that convergence is more highly valued than unity. This means that the process of coming together is more highly valued than the product of consensus. Thus, from this perspective the Web 2.0-facilitated collaborative design process becomes a matter of not hiring the best or most modern and futuristic designers, but the ability to assemble and construct a more stable network (Latour, 1987b), enrolling heterogeneous actors, including instruments, computers, the Internet, machines and materials, as well as managing the struggles and anti-programmes that might emerge during the design processes.

Whereas those who come from the traditional view of design education that is constructed around prescriptive design models would argue that the overall process of collaborative design can be taught, implying the scientific method of problem solving, the findings of this study indicate that it is indeed difficult to teach. Considering that Web 2.0-facilitated collaborative design is displayed as a messy practice, muddled, contingent and with unintended consequences which cannot be defined a priori, it cannot be accomplished following predefined stages of problem solving. In any case, Web 2.0-facilitated collaborative design cannot be likened to the scientific process of problem solving. In fact Cross (2006) has also argued that "designerly" ways of knowing is something extending beyond scientific knowledge. From this standpoint it can be argued that collaborative design skills cannot be taught by guiding student designers to go through predetermined sequential activities. The findings of this study indicate

that the overall process of conducting the Web 2.0-facilitated collaborative design is much more elusive and therefore almost impossible to teach outside the context of an authentic design project. The teaching of collaborative design skills therefore requires an experience-based learning environment which is dependent on iteration, repetition and continuous reflection throughout the process.

Design educators should therefore take advantage of Web 2.0 technology to create a design teaching and learning environment that enables student designers to be able to develop collaborative skills in an authentic design situation. Web 2.0 technology is able to create a design space that facilitates authentic dialogue in an open environment in which every student designer can freely share their ideas as they also consider other student designers' ideas at the same time. This allows student designers to engage in a dialogue that helps them to align their interests and come up with a common understanding of the design problem. Arguing from such a standpoint Latour (2005, p. 455) says "a common world, if there is going to be one, is something we will have to build, tooth and nail together". With regard to the design process what this means is that the observed process is a product of much building and 'tooth and nail' among the actors; it is a construction and is in a continuous process of becoming. Although the process gradually stabilises over time, it should generally be understood as open to ongoing changes as a result of actions by the participating actors, as well as any new actors that may join or leave the process. As such the design process is always in a state of permanent flux.

Another critical issue running throughout my discussion of Web 2.0-facilitated collaborative design is that it is a process that is constituted by the dialogue that takes place among the actors and the design situation itself. The findings of this study show that Web 2.0 technology creates an open dialogue among the designers, which mediates the translation of the design problem from an ill-defined, unstructured problem to an understandable and agreed upon interpretation of the design problem (Shafaat & Kenley, 2015). This translation becomes possible only when the designers take their time to discuss the design problem thoroughly in a free and open environment where each opinion is considered and debated before a common position is reached.

Now, if our future engineering designers are to be able to engage in collaborative design processes which are situated in dialogue, then they must be taught to understand, navigate, and translate what others in the design situation say and do. One consequent implication for the

future of engineering education is therefore how the issues of communication could be treated. Thus, design educators should encourage student designers to brainstorm multiple solutions and discourage them from settling on the first solution that comes to mind too early in the process (Gero & McNeill, 1997). Student designers should be taught brainstorming as a process of identifying multiple potential solutions, which need to be debated thoroughly before settling on one of them (Litchfield, 2008; Osborn, 1953). As such design educators should emphasise the importance of the ability to suspend judgement and to accept unusual ideas as qualities to be developed by student designers. Osborn (1953), suggests that suspension of judgement and welcoming unusual ideas are essential techniques for generating a substantial number of ideas.

Given that designers at most can only 'satisfice' that is, can only address design problems and develop solutions that are viable to some extent but can still be improved (Jonassen, 2011), the identification of this 'good enough' solution in a Web 2.0-facilitated collaborative project is not easy. Hence the teaching of reflective skills among design in Web 2.0-facilitated collaborative design projects becomes critical. In order to increase the chances of student designers picking the most 'satisficing' solution, the design situation must prompt them to reflect on their ideas and process. Their attention must be drawn back to the problem for them to address the design solution within the constraints and criteria. As noted by Jonassen (2011), multiple iterations are critical for improving the final product by reflecting on successes and failures. However, although iterations are critical to design they cannot be conducted indefinitely, time is a valuable resource and also a limiting factor. According to Householder and Hailey (2012, p. 29); "the reflection process should allow students to consider when additional time spent is more costly than the benefit yielded from that investment". The multiple iterations and reflections should be used to enable student designers to make important discoveries and explore challenges faced during the design process as well as making recommendations for redesign, among other things (Jonassen, 2011). In this regard design educators should realise the significance of using multimedia to represent ideas, including text, visual and audio, which is afforded by Web 2.0 technology.

Engineering design education should promote the use of media-rich communication technology such as is provided by Web 2.0 to facilitate the development of communication skills and reflective practice among student designers. This has been noted as the missing link in most engineering programmes (Jonassen, 2011). The only time when student designers' communication is put to the test in engineering programmes is when the students are asked to

present or promote their solutions at the end of a project. However, the type of communication which is important is rather the day-to-day interaction in the context of the unique design situations that the designers encounter. Reflection is required to critique design worlds, bridge gaps in understanding, and negotiate the continuous evolution of both the design problem and its solution.

7.6 Summary

The purpose of this study was to investigate and describe the actors at work and their agency during a Web 2.0 technology-facilitated collaborative design process. It is important to mention that the object of the study was not the design artefact, but the process that unfolds when a design artefact is produced. In line with ANT I analysed the collaborative design process in action when the forces of the network were at work. I analysed agency by following what actors caused other actors to do during the design process, extracting actors and their ties to describe the translation process in the actual collaborative design situations. Following ANT's principle of symmetry, this research recognises that technology and humans share the capacity of influencing society and meshing with each other, constituting hybrid social actors. This way of analysing the design process is different from the way that has been presented in the literature, where the process is projected as a staged or coherent linear process disregarding the role played by non-human actors.

As a framework of theorising I employed ANT's concept of actors, actor network, agency, mediation and the four moments of translation, being careful not to differentiate between non-human and human actors. My thesis is built on two premises. The first premise is that Web 2.0-facilitated collaborative design is a complex heterogeneous network constituted by both human and non-human actors, including student designers, design briefs, computers, Internet connectivity and the Web 2.0 technology used among others. Consequently, I analysed the design process as a complex socio-technical system explicitly integrating the social and technical dimensions of its complexity. The complexity of the process resulted from the rich information-driven interactions between the student designers which was made explicit on the Web 2.0 technology platform. These interactions were essential for the translation of the design ideas into the set of requirements and knowledge that were used to come up with the design solution.

The second premise of my thesis is that Web 2.0 technology is an emergent process. The finding of this study illuminates the concept of collaborative design as an emergent process resulting from the translations that take place among the various actors that are involved in the process as they transform the design problem into a design solution. I relied on the moments of translations, tracing how the design process emerged, how the actors were convinced and became allies in the network, as well as how they changed their minds without necessarily having to leave the network through the alignment of interests. Therefore, the way collaborative design was constituted in this study aligns with those who do not agree with the functionalist and instrumentalist approaches to design and hence argue for a shift to the way we use Web 2.0-facilitated collaborative design. Based on the ANT framework I used to conduct this study, I therefore proposed a new perspective on collaborative design, that is, collaborative design as an emergent process.

The inclusion of Web 2.0 technology in design practice calls to address collaborative design as an emergent actor network. In this study I demonstrated that the design process emerges and becomes successful when there are long chains of translations that are understood and distributed by involving many heterogeneous actors in the network. The translation process defines the identities of actors, their role, as well as the relationships that united them. Thus relationships formed among actors reveal which actors are participating and contributing to design the process. As such it was important that my analysis looked for the allies' part of the network and the translations to narrate the decisions taken and how others got to support, interact with, and devote their energy and resources toward something, how actors got enrolled, and which role they occupied. None of this was pre-given, it was co-constructed.

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APPENDIX A: Student consent form

Dear Student

I am a PhD student, registered at UKZN. I am conducting a study that focus on Using Web 2.0 technologies to facilitate the collaborative design process among undergraduate Engineering students.

I hereby seek your permission for you to participate in my study. You have been randomly selected from a pool of engineering students at Harare Institute of Technology (HIT). Please note that your participation is voluntary. Should you decide to participate in this study you would be expected to complete a questionnaire and or participate in an interview that will take not more than one hour of your time. I assure you of total confidentiality and anonymity as you will not be required to write your names on the questionnaire and the results of this finding will only be used for the purpose of my study. Please note that your participation in this study is voluntary.

Researcher: Lockias Chitanana **Promoters:** Dr. B.P. Alant/ Dr. D. W. Govender

Student No. 212561428

Cell (+263) 773 533 758

Declaration

As a participant in this study I understand that:

- My participation is voluntary, I am not being forced to take part in this study
- I may withdraw from the study if necessary
- I may refuse to answer any question on the questionnaire that requires information that is considered to be 'privileged' information
- Anonymity will be guaranteed at all times, my name will not be revealed on any documents to be completed or in the study
- Confidentiality will be guaranteed at all times, information gathered will only be used for the purpose of this study the researcher will not make information gathered available to any other person.

I _____ hereby conform that I understand the contents of this document and the nature of this study; I consent to taking part in this study.

I understand that I am able to withdraw from the study at any time, should I wish to do so.

_____ _____

Signature *Date*

Appendix B: Questionnaire for Students

The following questions are based on how the use of Web 2.0 tools supported you in your collaborative design project. Some questions are statements that you may agree or disagree with; other questions have positive and negative slants. Please tick the appropriate boxes below or write a short response.

SECTION A: DEMOGRAPHIC INFORMATION

1	Gender	Male	Female
	(Tick one)	40	18

2	Age Group:	18 -21	22-26	27-30	31-34	35-39	Above 40
	(Tick one)						

3	Year of Study	2nd	3rd	4th	5th
	(Tick one)				

4	What is your highest qualification?	'O" Level	'A' Level	National Diploma	Higher National Diploma
	(Tick all applicable)				

5	Have you had any work experience prior to your enrolment to this programme?	Yes	No
	(Tick one)		

6. If yes, please provide information on the following:

i. Your designation (what role?)
……
……
……

ii. Job description (specification?)

……
……
……

iii. Duration (how long?)_____ **(*Years/Months)***

SECTION B: GENERAL QUESTIONS ON WEB 2.0 FAMILIARITY AND USAGE BY STUDENTS

7. For how long have you used web 2.0 tools? _____

8. Have you ever used any Web 2.0 tools for linking with friends at your institution?

Yes ☐ No ☐

9. What kinds of Web 2.0 tools have you used to link up with:

(a) friends

i. _____

ii. _____

iii. _____

iv. _____

v. _____

vi. _____

(b) relatives

i. _____

ii. _____

iii. _____

iv. _____

v. _____

vi. _____

(c) classmates

i. _____

ii. _____

iii. _____

iv. _____

v. _____

vi. _____

10. Which one is your favourite Web 2.0 tool among them? _____

11. How can you judge your competence in the use of Web 2.0 tools?

Basic	rmediate	ced
9	17	17

SECTION C: STUDENTS' EXPERIENCES WITH WEB 2.0 DURING THE DESIGN PROCESS

12. List the Web 2.0 software you used to link up with team members during the design process?

i.	ii.
iii.	iv
v.	v.

13. How would you rate your ability to use Web 2.0 to contribute to the collaborative design project? (Tick in the correct box)

☐ More able than other students in the group

☐ About the same as other students in the group

☐ Less able than other students in the group

14. Indicate your judgement on the following statements with regards to your experiences using Web 2.0 tools during the design process.

(Please indicate your level of agreement to the following statements on the given scale by ticking the number that best describes your view on the statement).

Statement	**Strongly disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
I found the communication process in using Web 2.0 very fruitful.					
I found the process of linking up with team members using Web 2.0 tools easy.					
I found the process of negotiating with team members using web 2.0 tools very productive.					
I found the process of sharing design ideas using web 2.0 tools very productive.					
I found the collaborating in order to solve a design problem using this Web 2.0very fruitful.					
I found Web 2.0 helpful in meeting my design objectives.					
During this session I felt encouraged to contribute to achieving my design objectives.					
Overall, I felt that I was able to bring in ideas and thoughts to the design problem.					
Using Web 2.0 I had significant influence over what happened during the design process.					
Using Web 2.0my impact on what happened in the design process wasgreat.					
Overall, I found Web 2.0 helped me gain knowledge on the design process.					
Web 2.0 helped me in acquiring knowledge about the design process.					
Overall, I found Web 2.0 helpful for facilitating the collaborative session during the design process.					

Other: Please comment on any aspect of your experiences with Web 2.0 in collaborative design activities which you feel was not covered by the above statements.

SECTION D: ROLE PLAYED BY WEB 2.0 TOOLS DURING THE DESIGN PROCESS

15. Indicate your judgement on the following statements with regards to the efficiency of Web 2.0 tools in collaborative design activities.

(Please indicate your level of agreement to the following statements on the given scale by ticking the number that best describes your view on the statement).

0 – not used, 1 = not at all, 2 = to a limited extent, 3 – neutral, 4 =to a large extent.

Statement	**Not used**	**Not at all**	**To a limited extent**	**Neutral**	**To a large extent.**
Web 2.0 tools allowed me to share design information freely.					
Web 2.0 tools allowed me to link with team members easily.					
Web 2.0 tools allowed us to allocate responsibilities effectively.					
Web 2.0 facilitated efficient exchange of design information.					
Web 2.0 allowed us to integrate individual output effectively.					
Web 2.0 tools helped me to reflect on my design each time I visited the web site.					
Web 2.0 tools provided a useful way to reflect on ideas present by my team members.					
Web 2.0 tools presented us with an opportunity to put across our perspectives in an interesting way.					
Web 2.0 tools helped me to understand the range of my team members' perspectives easily.					
Web 2.0 helped me to make my contribution to the design project effectively.					
Web 2.0 tools made my learning of collaborative design issues more generally.					

Other: Please comment on any aspect of the efficiency of Web 2.0 in collaborative design activities which you feel was not covered by the above statements.

SECTION E: EFFECTIVENESS OF WEB 2.0 IN COLLABORATIVE DESIGN ACTIVITIES

16. Thinking about your experiences using Web 2.0 in the design project, please rate **how** your ability to do the following, has been affected.

1= Strongly Disagree 2= Disagree 3= Neutral 4=Agree 5=Strongly Agree

Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Improved my confidence in working as part of a team.					
Improved my ability to evaluate arguments and evidence so that the strength and weaknesses of competing alternatives can be judged.					
Improved my ability to explain my ideas to others.					
Improved my ability to be patient and tolerate the ideas or solutions proposed by others.					
Improved my ability to understand that problems may have multiple solutions.					
Improved my ability to use discussion strategies to analyse and solve problems.					
Improved my ability to recognise contributions or inconsistences in ideas, data, images, et.					
Improved my ability to identify the constraints on the practical application of an idea.					
Improved my ability to recognise flaws in my own thinking.					
Improved my ability to collaborate with others when working on a design project as a team.					
Improved my ability communicate effectively with others when working on a design project as a team.					
Improve my ability to effectively manage conflicts that arise when working as a team.					
Improve my ability to use feedback from others to improve solutions to a design problem.					

Other: Please comment on any aspect of the effectiveness of Web 2.0 in collaborative design activities which you feel was not covered by the above statements.

(Use the blank space provided on the next page for your comments.)

Thank you for your participation.

Appendix C: Semi-Structured Interview Guide for Students

Introduction

Before we start, I would like to thank you very much for giving me the opportunity to talk with you, and learn from you. As I mentioned, this interview should take about one hour. I would like to ask you some questions about your experiences in the design project. What I am interested in hearing about is how this project got started and developed, the influence or not of any to Web 2.0 tools on the process as well as the social and technical aspects that influenced your participation in this project. I am very interested in your personal views and thoughts and how you experienced your participation in this project.

(NB. These questions are grouped according to Callon & Latour (1992)'s ***'moments of translation'*** which involves the four stages, namely; Problematisation, Interestement, Enrolment and Mobilisation. The first category on background is meant for the researcher to get to know the participants and their experiences, familiarity with collaborative work and Web 2.0 prior to the project)

	Question to be asked	**Comments**
1. Background	**1. Background Information on Interviewee** 1.1. Could you please tell me about your academic background? 1.2. Can you tell me how worked with your team members before the project started? 1.3. Can you comment on your level of comfort or competence in the use of Web 2.0 tools? 1.4. What was your role in the design project?	Identifying key Actors
2. Problematization	**2. Project Formation: who set the stage for the project?** 2.1. Can you please describe how this design project got started? 2.2. What were you initial thoughts about the design project? 2.3. Who set the initial goals of the design project 2.4. How were these goals set? 2.5. Did the initial goals change in any way during the course of the design project? 2.5.1. If so, how so? 2.5.2. How you use Web 2.0 tools to negotiate the changes and how did the changes affect the design project? 2.6. Can you please tell me how the project activities were initially defined and negotiated? *2.6.1.* How did you use Web 2.0 tools in the process? 2.7. Were there changes during the project (e.g., distribution of roles, organization of work, etc.)? 2.8. When the project started, do you think that all the project participants had the same expectations regarding the project outcomes? *2.8.1.* If no, what were the different expectations? *2.8.2.* If yes, what were similar expectations? 2.9. How did you use Web 2.0 tools to align these differences?	Establishment of the Obligatory Passage Point (OPP). Definition of goals of actors, setting rules and ways operation.

3. Interessement	**3. Convincing others to work on the design project** 3.1. Can you please tell me how the project group was formed? 3.1.1. How did you personally come to be involved in the project? 3.2. Did you have already established ties with other project participants (e.g., had you already worked together, etc.) when the project started? 3.3. How did you use Web 2.0 tools to link you up with project partners?	Negotiating with to persuade them to identify with their roles- (Creation of networks, finding common ground, mutual trust)
4. Enrollment	**4. Acceptance of the design project** 4.1. How did you get others to work on the project? 4.2. To what extent would you say Web 2.0 tools helped you to get your team members to work on the design project? 4.3. How did you use Web 2.0 tools to get others to work on the design problem? 4.4.	Establishment of stable network alliances, through either coercion, sedation and/voluntary participation
5. Mobilization	**5. Adoption and development of the design project** 5.1. How did you use Web 2.0 tools to organise work in the project? 5.2. Was there a distribution of roles in the project? 5.3. How did you use Web 2.0 tools in the distribution of roles? 5.4. How did you use Web 2.0 when you encountered a problem? 5.5. Were Web 2.0 tools used to interact outside scheduled learning time? Please explain?	How the proposed solution gained wider acceptance

Conclusion

Do you have any questions for me?

(I have to ask permission to follow-up on issues by telephone/email

Thank you for your time!

Appendix D: Turnitin Report

- preferences

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