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Tracing sources of design uncertainty and controversy in Web 2.0 facilitated collaborative design process

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ABSTRACT

The integration of Internet-based collaborative tools such as Web 2.0 technologies to facilitate the design process has rendered collaborative design a chaotic practice filled with controversy and uncertainty, with the inevitable risk of unintended consequences. The purpose of this study was to trace the sources of design controversy in a Web 2.0 facilitated collaborative design process. The study employed an Actor Network Theory (ANT) methodological framework to explore design controversy in five design teams comprising of 4 to 6 undergraduate engineering students. Data was constituted by following the traces left by the actors, both human and nonhumans, their actions and the associations they made and broke as they worked to provide a solution to a design problem. All of these traces were captured on a Web platform. Our position was that of non-participant observers to allow the participants to speak for themselves. In addition, some key participants (spokespersons) were interviewed to allow them to explain their actions. The findings of the study demonstrate that Web 2.0 technologies played a critical role in illuminating controversies encountered during the design process from the design group formation, design problem analysis, as well as the generation and realization of the design solution stages of the process. Web 2.0 technology enabled the tracing of the rich interactions among designers which allowed the mapping of provisional ties, and the translations that made these ties durable and seemingly irreversible.

Keywords

Actor network theory, Collaborative design, Design controversy, Web 2.0.

INTRODUCTION

Design has become a more complex collaborative activity, going beyond straightforward sequential problem solving processes to become a highly interdisciplinary and controversial task of a designer multi-actor system (Gaver, 2012). Design is now a process where various interpretations and interests

are translated into technical solutions as well as organizational arrangements and procedures to be followed in providing a solution to the design problem. It is now a complex process of drawing things together by ensuring that conflicting interests are aligned. The process of achieving alignment of conflicting interests is dependent on the translations that take place among the actors. However, the common views of design fail to capture this complexity for us to have a full understanding of the design process as it is now practiced. In fact, with regard to design, Latour (2008, p. 12), argues:

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.

Design controversy manifests itself when the actors in a design project realize that they cannot ignore their different views on the design project and it ends when actors manage to work out a solid compromise to live together (Venturini, 2010b). We use the term ‘controversy’ in its widest sense as “situations where actors disagree (or better, agree on their disagreement)” (Venturini, 2010b, p. 10). As such, controversy points to a series of uncertainties that a design project undergoes. It involves some disagreement that takes place among different actors over the decisions that are taken in the design project.

In this paper, we employ ANT principles to explore design controversy by following the traces left by the actors (human and non-humans), their actions and the associations they make and break as they work to provide a solution to a design problem. Following a controversy as it unfolds, that is, controversy mapping, allows the normally hidden social dimensions of science and technology to unravel and makes them more explicit (Callon, 1986a; Pinch & Leuenberger, 2006). Controversy mapping is a research method developed from ANT and has been applied by researchers such as Yaneva (2012) to investigate design processes in architecture. According to Yaneva (2012, p. 6) “controversy mapping provides us with inventive narrative techniques to gain access to the particular and grasp the unique.” Controversy mapping uses cartographic methods to represent actors’ disagreements over *matters of concern* in controversies (Venturini, 2010b). In other words, mapping design controversies entails analyzing controversies and describing them using a variety of representational techniques and tools that permit us to describe the successive stages of controversies. Mapping the dynamics of a controversy in design opens it up to informed scrutiny that leads to a better understanding of the circumstances that surround it. Owing to its rich tradition of semiotics, controversy mapping provides a method of inquiry that questions the traditional epistemology of social sciences (Latour, 2005; Venturini, 2010b) and comes out with a new understanding of design as a matter of concern. Certainly, mapping the controversy surrounding Web 2.0-facilitated collaborative design would enable us to present some new ways of visualizing the dynamics of controversies ushered into the design process by the new and emerging design tools (Yaneva, 2012).

LITERATURE REVIEW

PRESENTING DESIGN AS A MATTER OF CONCERN: AN ANT VIEW

Design, as a collaborative process, is now viewed as an activity that involves different actors, dealing with different and potentially independent factors of an artifact, all situated within the specific circumstances of the design process. The developments in Internet based collaborative tools have

propelled collaboration in design projects further. With the advent of Internet based collaborative tools such as Web 2.0 technologies, design has become a chaotic practice with the inevitable risk of unintended consequences. Owing to the open networks of actors enabled by Web 2.0 technology, together with the changing demands of the user community, designers are increasingly confronted with uncertainty concerning the object of design. There is evidence from various websites, blogs and forums of design experts who are seized with issues of uncertainty in design knowledge and risky designs that are showing some polarized opinion. Examples of such forums include the *Auto Prophet* (<http://theautoprophet.blogspot.com/>), a blog that deals with design issues in the auto industry, the *Engineering Pathway*, (www.k-grayengineeringeducation.com/blog/index.php/) a blog that deals with various design issues and engineering education and the *Machine Design Blog*

(http://blog.machinedesign.com/Machine_Design_Blogs), a blog that offers commentary and opinions in all matters of engineering as well as a section for feedback where readers are free to agree or disagree with blog contents. Furthermore, owing to the increased complexity in today's design problems, design has become a very complex process, which requires additional organization, negotiation and building of shared understanding on *matters of concern*. In such an open and heterogonous network of allies, the design process is the outcome of drawing things together, conducted by mobilizing and enrolling actors through translations of goals.

ANT provides us with a theoretical and methodological toolkit, which can be applied to the study of the collaborative design process; where we can view the collaborative design process as a network of actors in a socio-technical system. From an ANT perspective, the design process therefore comprises a network of actors both human, for example designers, users and community and nonhuman, for example drawings, convention and materials. This network of human and non-human actors come together around matters of concern and controversies since the design artifact is the point at which it is not yet finalized or *black boxed* (Venturini, 2010b). In this paper, we argue for the conception of design as matters of concern rather than matters of fact as presented in the modernist-positivist approaches to design. Latour (2005), proposes the notion of "*matters of concern*" as opposed to the more common scientific approach of "*matters of fact*". According to Latour (2005), while matters of fact are developed without consideration of desire, that is, moral, ethical and others, matters of concern embrace and are centered around those desires. Whereas matters of fact exist without context, in an attempt to explain the indisputable matters of concern are located in contexts, disputing both the possibility and the efficacy of indisputability.

Design research, which has challenged the technical rational approach to design, contends that in all design projects, designers are always dealing with wicked, ill-structured, and vague constructions of reality. During the design process, constructs-- which need interpretation-- are constantly negotiated and exchanged. Such realities can therefore not possess one meaning for them to be considered as matters of facts. The interpretation and meaning given to them is dependent on the actors involved. Additionally, actors in a design project are bound to differ both in the ways in which they view the design problem and in how they communicate and represent the design solutions they are proposing. This dimension has been missing in all the perspectives that have been put forth to explain the design process. According to Latour (2008), what has been missing in most descriptions of design are the controversies that the designers experience. What we need, therefore, is a new perspective; something other than the single-point perspective, to capture what has been missing in the description and presentation of the design process. We need a theoretical framework that can illuminate the conflicting nature of things in design.

Describing design as a process of engaging designers around particular issues or "*matters of concern*" suggests that design can be employed as a means to explore and intervene in emerging socio-technical

matters. Even if we consider the view that design is redesign, then design is reactionary and not revolutionary as presented in the modernist viewpoint. The design product itself is a sign to be interpreted. It is, therefore, not a *matter of fact*. Like other contemporary design theorists, Latour sees design as normative-- having both the material and moral dimensions. This is why design could be extended to other areas such as politics. Latour challenges us to visualize matters of concern for the designers. He suggested that we need to 'represent, assemble, draw together *'matters of concern,'* and map controversy. In other words, design controversy refers to a situation where designers are embroiled in various uncertainties surrounding design, which are not simple matters of fact but complex matters of concern. To deal with matters of concern, Latour identifies five sources of uncertainty, which we should consider if we want to study networks such as design networks. These include: no group, only group formation, action is overtaken, objects too have agency, matters of fact or matters of concern and writing risky accounts (Latour, 2005). In addition to matters of fact versus matters of concern, in this paper we concentrate on group formation of uncertainty in agency of non-humans.

Uncertainty in group formation

According to Yaneva (2009, p. 282) "design is a way of producing additional attachments that make a variety of actors congregate, forming different groupings and assembling social diversity." Latour (2005) argues that there is uncertainty surrounding such group formations and group enrolment. The major uncertainty he notes is that "there is no relevant group that can be said to make up social aggregates, no established component that can be used as an incontrovertible starting point" (Latour, 2005, p. 29). He further argues that "groups are not silent things, but rather the provisional product of a constant uproar made by the millions of contradictory voices about what is a group and who pertains to what" (Latour, 2005, p. 31). In other words, to understand the social, Latour urges us to move beyond social explanations because he sees them as carriers of well-worn platitudes with no relevance to the actors they claim to explain. Sociologists take the word social to designate an already assembled bundle of ties or established state of affairs (Latour, 2005). Nevertheless, Latour (2005, p. 28), argues that we should not assume "that a group is a stable entity; rather, groups are considered dynamic, constantly reforming aggregates of actors". Casting uncertainty around groups, he notes that, "relating to one group or another is an on-going process made up of uncertain, fragile, controversial, and ever shifting ties ... actors are *made to fit in a group*". In other words, there is "no group, only group formation" (Latour, 2005, p. 27). The formation of groups is always in progress; the actors are constantly being wooed by or wooing others to an emerging group. As Latour insists, social ties that form social aggregates or groups do not simply exist on their own virtue, but they are actually performed. Since formation is a process, the actors must be performing work on the group in order to prolong its existence. We can only discern groups or the possibility of groups when the actors have defined such groups. Instead of looking at intermediaries, ANT argues that we look at mediators as the means that produce the group. This is mainly because an intermediary dissolves into the effect of a given cause without any impact on the group's transformation or translation. This is opposed to mediators who are capable of translating and transforming the causality as they relay the message as it comes through them.

A group must have a spokesperson. Key to tracing controversial group formation is that groups are made to talk via spokespeople, the group makers or group stabilizers. For researchers, the material impacts of the efforts to include and exclude members makes it possible to trace group formation. Professional (in this case) designers with all their specialized tools are, in Latour's terms, interested and made to act usually as spokespeople (Latour, 2005).

Uncertainty in the agency of non-humans.

ANT argues that the actions of non-human actors as the outcome of a controversy cannot be explained by reference to the social realm alone (Callon, 1986). This is because action is not simply related to a particular agent or explained by enduring historical structures. Actors manifest their agency in two ways. Since the agency that is shown in action is not positively and wholly attributable to any particular actor, there is no actor who is considered the sole originator of an action (Latour, 2005). Firstly, actors may carry and transmit the message or forces they receive without transforming them, and these are known as intermediaries. Secondly, actors may transform or translate the messages or forces into messages or forces that serve other interests than those by which the actor received them. When they act in this manner, they are defined as mediators.

ANT's critics challenge Latour's ontological proposition that seems to equate human and non-human agency (Kirsch & Mitchell, 2004). However, the point that Latour tries to address is the question of agency being a profound uncertainty. He thus argues:

... the human-non-human pair does not refer us to a distribution of the being of the pluriverse, but to an uncertainty, *to a profound doubt about the nature of action*, to a whole gamut of positions regarding the traits that make it possible to define an actor (Latour, 2004a, p. 73).

Thus, the task of an ANT analysis is neither to resolve this uncertainty by explaining which kind of agency belongs to humans or non-humans, nor to declare human and non-human agency to be equal (Holifield, 2011). Instead, the analysis is interested in discerning as many mediators as possible and is free to ignore all intermediaries as they do not affect the processes under investigation. As such, an ANT analysis needs to acknowledge the potential that non-humans or objects hold to mediate messages or forces, either by right of their own unique characteristics as receivers and transmitters of force or by right of their use by humans to extend the reach of human agency. However, the view that non-humans or objects have agency should not be taken to mean that they can exercise intentionality. We should also not infer some traces of technical determinism. Rather, their agency is conferred by humans (Law, 1992). As actors, objects might allow, produce, structure, define, negotiate, authorize, encourage, influence or prevent certain social outcomes. Thus the social world can be "understood as an entanglement of interactions" among humans and non-human (including plants and animals) agents (Latour, 2005, p. 65).

WEB 2.0 TECHNOLOGY: AN ANT PERSPECTIVE

There is no single agreed upon definition for Web 2.0. Like many important concepts, Web 2.0 does not have a hard boundary, but rather, a gravitational core. Generally Web 2.0 is a grassroots term used to describe the online phenomenon resulting from newly evolving Internet technology infrastructures (O'Reilly, 2005). It is used to describe the current state of the Internet as it compares to the early days of the Web, characterized by greater user interactivity and collaboration, more pervasive network connectivity and enhanced communication channels. Web 2.0 applications mainly describe applications that empower users to create content, share this content with anyone they invite and make connections with existing offline contacts or add new contacts to their social network. This phenomenon was popularized by large content portals such as (e.g., MySpace), blogs, wikis (e.g., Wikipedia), instant messaging (e.g. Skype), and personal content sharing portals, for example,

Flickr, Google Video, YouTube and podcasts). These applications are some of the common examples of the Web 2.0 technologies that are transforming users' experiences with the Internet in contemporary society. The most cited definition of Web 2.0 is the one given by O'Reilly (2005, p. 13) who says:

“Web 2.0 is 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.”

The above definition 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 actors define one another according to ANT, 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). Therefore, in this paper, we view Web 2.0 as not only the web-based applications, but also the development and delivery of web services that give users control over how they can participate in a network. As such, we take Web 2.0 as a new epoch of the web that is not only represented by simply new technological features (Cormode & Krishnamurthy, 2008), but a phenomenon that 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 2.0 as a social construct that has no easily identifiable elements, since both the social and technological dimensions of the technology are interweaved more than ever. Considering Web 2.0 technology as a set of uses or applications highlights the benefits and major applications of and for the set of tools that the technology provide us (Depauw, 2008). This view gives Web 2.0 its significance as an actor in the collaborative design process. When applied to Web 2.0-facilitated collaborative design, tools per se do not shape the collaborative design process, but as Depauw (2008, p. 4) argues, “indeed, they order and form the medium of the network they describe”. Thus, ANT allows us to view Web 2.0 facilitated collaborative design process as effects initiated by interacting actors who mobilize intermediaries (Web 2.0 tools) that assemble and stabilize the collaborative design network. This ANT view allows us to view Web 2.0 based networks as effects initiated by interacting actors who mobilize intermediaries that stabilize the network.

The development of Web 2.0 and internet networked technologies has provoked a broad interest in the activities of knowledge creation and sharing. The services offered by Web 2.0 have transformed the Internet by making users become producers of information. Web 2.0 technology enables community based input, interaction, content sharing and collaboration. The technology offers the possibility for users to distribute their ideas and creative works by posting and commenting as many often read from the platform (Horowitz, 2006). For example, RSS has made weblog different from an ordinary web page; it has turned weblogs from an *ease-of-publishing* phenomenon into a *conversational mess of overlapping communities*. For the first time, it became relatively easy to gesture directly at a highly specific post on someone else's site and talk about it. Because such levels of interaction, chat and

discussion emerged, entrenched friendships emerge as a result (Coates, 2003). As such, the fundamental ideas underlying the use of Web 2.0 is that successful network applications are systems for harnessing collective intelligence (O'Reilly & Battelle, 2009). It is further noted that collective intelligence applications depend on managing, understanding, and responding to massive amounts of user-generated data in real time (O'Reilly & Battelle, 2009). If harnessing collective intelligence is the essential part of Web 2.0, it is prudent that designers leverage this technology to facilitate the collaborative design process. In this view, collaborative design could be, as we have discussed earlier on in this review of literature, "understood as an entanglement of interactions" among actors, humans and non-humans (Latour, 2005, p. 65). The ever-increasing complexity in design problems coupled with the high levels of entanglement in collaboration enabled by Web 2.0 technology demands has increased uncertainty and controversy in the design process. The controversies involved in the collaborative design process could have remained practically invisible were it not for the introduction of Web 2.0 phenomenon. Web 2.0 technology provides us with abundant resources to follow controversies surrounding the collaborative design process. In the next section, we describe how we assembled an ANT based research methodology that we employed to trace the controversies encountered by student designers as they were involved in Web 2.0 facilitated collaborative design project. We found an ANT based methodology to be the most suitable approach mainly because of its low-normative epistemological proposition, which encourages researchers to hold no a priori definitions, but to allow explanations to emerge and be accounted for from the actors and practices under study (Storni, 2010; Yaneva, 2009).

METHODOLOGY

The methodological approach used in this study was influenced by ANT. ANT is a research approach that was championed by Michael Callon, Bruno Latour and John Law, who proposed it as a methodological toolkit for Science and Technology studies (Callon, 1986b; Latour, 2005; Law, 1999, 2004). It was originally viewed as a sociology of science. ANT's application in research was later extended to include studies that dealt with technology, where its latest application is in Information Technology. It is a theory that can be used to represent work that in reality is difficult, messy and complex (Landberg & Sandahl, 2000). ANT-based methodologies assist in tracing the relations in actor networks, managing and mapping controversies in projects and encourage active participation and communication between different stakeholders (Finegan, 2012). It does this by providing a lens that helps to simplify the complex process by highlighting how human actors and non-human actors are intertwined in order to reach initially set goals. This results in a constructive approach that allows researchers to assemble the subject as richly diverse, historically situated, infinitely complex and engaged with its own inherent contradictions and controversies. In Latour's words, such an approach would result in, a "multifarious inquiry launched with the tools of anthropology, philosophy, metaphysics history, and sociology to detect how many participants are gathered in a thing to make it exist and maintain existence." (Latour, 2004b, p. 246).

ANT can offer a plausible comprehension of socio-technical relations from a relativist view of the nature of modern society (Law, 1999), in which the social and the technical are gathered in the same analytic view (Law, 1999). Since we consider the design process as a co-evolution of technology with technology, using ANT offers us reasonable understandings and explanations about the increasing hybridization of humans and computer technologies (Walsham, 1997). Therefore, ANT can be a suitable methodological framework to show how new technological artifacts such as Web 2.0 impact design practice.

DATA CONSTITUTION

In controversy studies, the researcher should not constrain the observation to any single theory or methodology, but should rather observe the phenomenon from as many viewpoints as possible and listen to actors' voices more than the researcher's own assumptions (Venturini, 2010a). In the same vein, the researcher has to bear in mind that in an ANT approach, controversies involve all kind of actors. In order to illuminate the role of Web 2.0 technology in design controversy, we took Venturini's advice that when looking for controversies one should search where collective life gets most complex. According to Venturini (2010a, 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 quarrelling; where conflicts grow harshest.

Furthermore, Callon (1980) notes that these zones of controversy and uncertainty are not defined through logical deduction from the existing body of knowledge, nor are they a result of straightforward influences. This shows that design controversies are certainly a complex phenomenon to observe and trace. However, traceability is an intrinsic affordance of digital media; everything that is mediated is automatically traceable. Anything said or done in a digital environment is traceable. This in a way answers Latour (2008, p. 13), where he asks; "where are the visualization tools that allow the contradictory and controversial nature of matters of concern to be represented?" It was possible to pick the traces left behind by the actors including the time they spend on an activity, issues they pondered, and all the twists and turns of the discussions they engaged in.

To collect data, we took advice from Latour where we followed the actors picking the trace left by the actors on the various Web 2.0 technology platforms used during the collaborative design project. Our position was that of non-participant observers to allow the participants to 'speak' for themselves. In addition, we interviewed some key participants (spokespersons) to allow them to explain their actions. Through following the traces left by the actors, we were able to identify the different controversies that the designers in this study encountered during the design process. We mapped the actors' main statements and traced the thick mesh of relations among the statements that circulated in controversy. In the next section, we present findings of our analysis of the data.

RESULTS

In this section, we illuminate the design controversies that were encountered by student designers, paying particular attention to the mediation role played by Web 2.0 technologies. We use four of Latour's (2005) five conceptions of sources of uncertainty: the nature of groups, nature of actions, nature of objects and nature of facts, to glean out from the data the themes around controversy in a Web 2.0 facilitated collaborative design undertaken by teams of undergraduate engineering students. 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. Drawing from Latour's (2005) sources of uncertainty mentioned above, our 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 constitutes a collaborative design team
- Controversy over what constitutes the design problem
- Controversy over what constitutes the design solution

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

THE ROLE OF WEB 2.0 IN CONTROVERSY OVER WHAT CONSTITUTES A COLLABORATIVE DESIGN GROUP

The controversy over what constitutes a collaborative design group refers to the process of group formation and the identities of the actors. First, actors are identified in their action. When there is no action, then there is no actor and group to talk about. As such, groups are dynamic, they are ever changing and provisional, constantly made and dissolved. The data we collected shows that actors involved in the collaborative process were constantly grouping and regrouping. Data show that changes to the teams were triggered by the free, networked actions of the different actors who were enrolled in the design teams during the course of the design process. The elusive, unfolding nature of online groups made it difficult, if not impossible, for the focal actors for each team to establish who would constitute their group beforehand and during the design process. Uncertainty with respect to who constitutes a team was high at the beginning of a project. This is because no group existed prior to the initiation of a project. The following quotation from one of the design group spokespersons illustrates this:

Aha! They just said organize yourselves into groups of four. We then just organized ourselves according to the level of friendship. (Group A)

Although some design teams were at their embryonic stage, as implied by the statement from one of the spokespersons during interviews, the teams grew in unpredicted ways.

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 [our] strengths and weakness. So within that we managed to form a group. (Group B)

This was due to the ability of Web 2.0 tools to entice and recruit unforeseen members to the design team. For example, Facebook's like function was able to recruit some experts and even non-design people to become members of the teams, even temporarily. Since members are identified in action, according to ANT, actors of the constitution of the groups were not static. For example, loss of connectivity rendered some team members inactive, thereby excluding them from the team. However, such members would rejoin the group when their connectivity was restored. Invitations to rejoin the design teams were on several occasions sent by Facebook messages to potential members. This shows that action, and therefore agents, were not restricted to the students as human actors, but the Web 2.0 tools employed by the student also exercised their agents too. For example, Web 2.0 tools such as Facebook were active members of the group and in many instances took the role of the group's spokesperson, when for example, they persuaded students to consider joining or rejoining the design teams.

Controversy surrounding the constitution of design teams in a Web 2.0-facilitated collaborative was due to the almost endless list of actors involved in the design process (Latour & Hermant, 2010). 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. Consequently, the collaborative design teams could never be a pre-existent thing, but is always assembled and reassembled afresh through association. A design team

had to be assembled and this involved the focal actors or 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 come up with their own interpretation of the issues discussed. The seamless working space created by the Web 2.0 technology permitted a high degree of openness and flexibility in the network, which resulted in continuous debate that generated more controversy. However, in most cases the human spokesperson exercised some degree of power that he or she obtained through association with the lecturer and experts whom 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 in Box 1 below illustrates how the spokesperson exercised their power.

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 enroll enough actors in his or her program of action. The enrolment and mobilization 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.

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.

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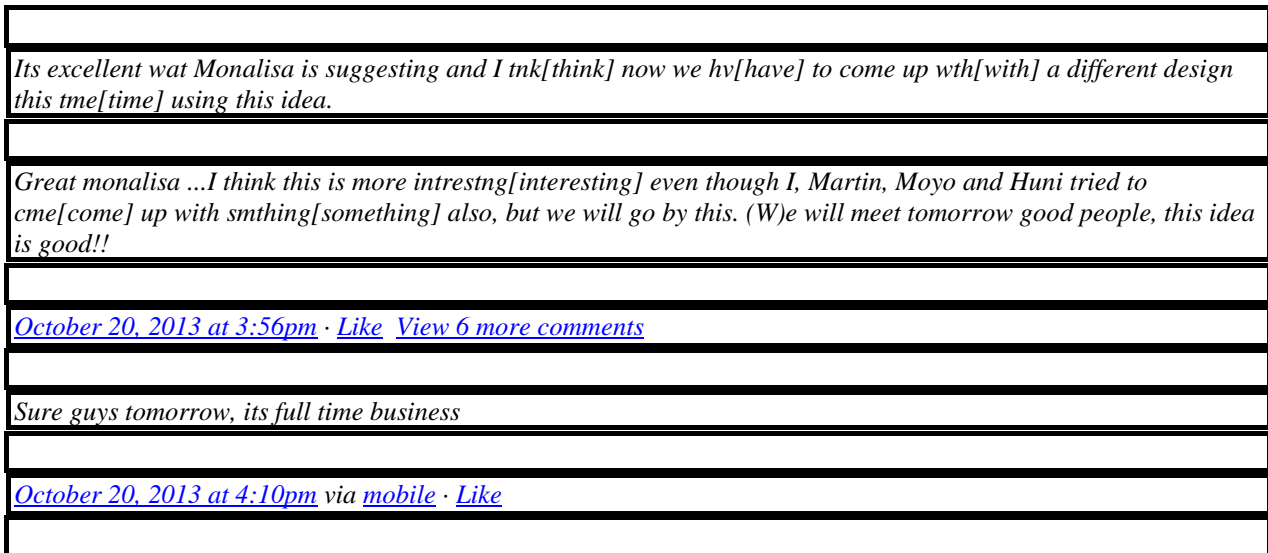
Box 1: Facebook Conversation among design group members

ROLE OF WEB 2.0 IN CONTROVERSY ON WHAT CONSTITUTES THE DESIGN PROBLEM

As regarding 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). 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 or ill-defined (Rittel & Webber, 1972), 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. Each student designer had his or her own understanding of the design problem and therefore a different way of thinking with regards 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. A design

solution presented problematic situations associated with the multiple alternatives from which to choose. Web 2.0 mediated the alignment of ideas by making such information explicit. The student designers needed to gather and analyze the information that was required to make decisions.

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. The quotation in Box 2 below illustrates this point.



Box 2: Facebook conversation among design group members

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. In most cases, uncertainty associated with having multiple alternatives was desirable since it encouraged designers to explore as much of the design space as possible. 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 agreed to think in a particular way and act in ways that maintain the network (Walsham & Sahay, 1999). This is also demonstrated in the quotation above when the student designers agree to work on a 'good idea'.

ROLE OF WEB 2.0 IN CONTROVERSY ON WHAT CONSTITUTES 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 Group B)

In a Web 2.0 facilitated collaborative design process, controversy over what constitutes a solution to the problem is more problematic in that every designer has an opportunity to present his or her ideas and to be heard. Such a multiplicity of views, which could be traced on the Web 2.0 technology platform, are not easy to ignore and coming up with an agreed satisfying solution is problematic. This results in a multiplicity of possible solutions to choose from, but there is no single perfect solution to a design problem. Since there is no one absolute solution, designers can only settle for choices that satisfy the problem definition at the point in time (Whelton & Ballard, 2002).

However, Web 2.0 technology played a critical role as mediators in the selection of a possible solution to the design problem. Web 2.0 tools went further than providing a space for dialogue. The tools become actors in shaping the solution to the problem. For example, the technology transformed the inscriptions that were circulated through it in ways that provided student designers with an alternative way of making representation of the design problem and its envisioned solution. By so doing, the technology assumed the role of a spokesperson that could speak on behalf of the group. Once an agreed solution was reached, Web 2.0, as spokesperson, guided student designers to define the design problem in a way that constrained the number of possible responses from among them. The dialogue that took place on the Web 2.0 and the intermediaries that were circulated mediated the alignment of interests among student designers by accommodating and constraining how other actors could orient themselves towards the proposed solution. By so doing, Web 2.0 technology ensured that students sought for consent by other student designers to embark on the proposed design solution.

DISCUSSION

We 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). Furthermore, literature has also established that in all design projects, the designers are always dealing with wicked, ill-structured, and vague constructions of reality. Owing to the multi-actor interactions involved in the created design network and the wicked nature of design problem, controversies are bound to occur. The analysis shows that various controversies are always encountered among the actors that affect the way the collaborative design process is constituted. 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. Such realities can therefore not possess one meaning for them to be considered as matters of facts. For example, what constitutes the correct interpretation and understanding of the design problem and its solution cannot be considered as a fact but as a matter of concern. There is no one way of knowing and understanding what constitutes the design problem and its solution. During the design process, constructs that need interpretation are 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 then should be seen as a place where this uncertainty can be dissolved through a free and open dialogue that allows student designers to express themselves in ways they prefer most. Given this situation, the role of the focal actors becomes critical. The focus actor is needed as the spokesperson to guide designers in dialogue using the Web 2.0 technology platform to help designers work upon, transform, link, merge

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

It was also evident that in Web 2.0-facilitated collaboration, design controversy takes on added dimensions, since agency is distributed throughout all 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 is not only to be looked for among human actors, but some taken for granted are non-human actors that also need to be followed in order to illuminate the plurality of conflicting items. According to Venturini (2010b), controversies involve all kinds of actors, not only human beings and human groups, but 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. It is also evident that, controversy in Web 2.0 technology-facilitated collaborative design is not necessarily negative and therefore undesirable. It is indeed both positive and negative. Design controversy is desirable because it opens up 'black boxes', things and understandings that otherwise will be taken for granted (Yaneva, 2012). 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 the selection of a poor alternative. Although it was beyond the scope of our 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. It is therefore crucial that designers, with the help of the team's spokesperson, 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 the alignment of their conflicting views and aspects of design process.

CONCLUSION

Conclusively, the way in which Web 2.0 technologies facilitated collaborative design was that it dealt with controversies present in the design process in its most dynamic form. We have also demonstrated that Web 2.0 technologies played a critical role in dealing with controversy during the design process by enabling rich 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, our analysis shows that Web 2.0 technologies provide insights into how these may be dealt with to keep the design network stable, even momentarily.

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