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The role of Web 2.0 in collaborative design: an ANT perspective

Lockias Chitanana[1]

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Abstract
This paper analyses Web 2.0 facilitated collaborative design among undergraduate engineering students. The study used the actor–network theory as a methodological and analytical framework to study the role of Web 2.0 technology in the collaborative design process. Participants were drawn from fourth-year engineering students at a university of technology in Zimbabwe. Data were constituted by using a questionnaire, comprising closed and open-ended questions, semi-structured interview schedules, observation schedules, and non-participant observation of online activities by student designers. The findings of the study show that Web 2.0 technology stirred the collaborative design process by stimulating unpredictable actions, thus actively contributing to shaping the emerging collaborative design network. The study concludes that Web 2.0 technologies should not be viewed as simple tools for communication, as described in some literature but as non-human actors which can mediate the collaborative design process and shape the way it is constitued and carryed out in practice.

Keywords Collaborative design · Web 2.0 · Actor–network theory

Introduction

This paper refers to a study on Web 2.0 facilitated collaborative design among undergraduate engineering students (Chitanana 2016). The study by Chitanana (2016) shows that the design space has been transformed because of the adoption of the Internet as a tool to facilitate the design process. Previously, as explained by Schon's studies, the design studio has been the traditional space where design was taught and practised (Schon 1983, 1984). It provided an environment for collaborative, learner-centred and experiential problem-based teaching (Kurt 2009) through social interactions between instructors and learners and among learners themselves (Ismail and Soliman 2010; Pringle 2009; Schon 1984). The design studio allowed students to communicate, interact, and discuss with their peers, design experts, and professionals (Kamalipour et al. 2014). However, the ever-increasing complexity of design problems coupled with the developments in ICT have rendered the

✉ Lockias Chitanana
chitananal@staff.msu.ac.zw

[1] Department of Educational Technology, Midlands State University, Gweru, Zimbabwe

traditional design studio inadequate to facilitate the effective teaching and learning of design commensurate with current trends in almost all design fields of engineering and architecture. In response to the changes, some developments have taken place in the versions of the design studio. For example, the Virtual Design Studio (VDS) emerged in the early 1990s, almost parallel to the coming of the Internet as the first attempt by design educators to respond to the demands of today's design problems (Schnabel and Ham 2013; Smithers 2010). The VDS is a designing space that leverages the affordances offered by the virtual environment to expand studio space beyond the physical and time limits of the traditional design studio (Pektas 2015). It is characterised by its ability to broaden the space and time boundaries, presenting opportunities for designers to interact and communicate using computer-mediated and computer-supported platforms.

In this paper, we shall take the term Web 2.0 to refer to the second generation of user-centred web applications and online services that promote social connectedness, media and information sharing, user-created content, and collaboration among individuals (Wilson et al. 2011). The most common of these technologies are blogs, wikis and social media which are collectively referred to as Web 2.0 platforms. Web 2.0 platforms bring a shift from the passive experience of static 'read-only' web pages to the participatory experience of dynamic and interactive web pages (Hossain and Quinn 2012; Paroutis and Al Saleh 2009). As a result of the introduction of Web 2.0 technologies in design education, the only logical step to develop the VDS was to leverage the social and collaboration affordances of the technology to advance the teaching and learning of design (Schnabel and Ham 2012). Web 2.0 technology and social network media, in particular, have been integrated into the design studio, resulting in the Social Network Virtual Design Studio (SNVDS). Coupled with the widespread student access to the Internet and various forms of mobile computing devices, Web 2.0 technology has a potential to facilitate a more engaging design learning environment that intersects various physical and virtual realms as well as the social and cultural elements of the design (Ham and Schnabel 2011, 2012). It is against this background that this paper seeks to illuminate the role of Web 2.0 technology in collaborative design.

Purpose of the study

Nonhumans have been relatively under-researched as key actors in collaborative design (Palmås and von Busch 2015; Tolbert et al. 2016). Where there has been some research on the role of nonhumans in collaborative design, the focus has been on the equipment and materials used as design tools, for example, pencils, paper, buttons, textiles, computer modelling or other media (Akama 2015; Binder et al. 2015; Brandt et al. 2013; Craft 2013; Lindstrom and Stahl 2012; Schoffelen et al. 2015). Nevertheless, there is a growing interest among design researchers to include nonhumans as co-designers, for example; examining animals (birds) as 'code signers' (Jönsson and Lensskjold 2015); memos and reports as meaning-makers in the design process (Tolbert et al. 2016); investigating a 'quisling' whose agency is nonhuman (Callon 2004). However, there is still a very clear dichotomy in collaborative design between human participants on one side and nonhumans on the other (Andersen et al. 2015). In trying to address this gap, Palmås and von Busch (2015) studied participatory design as a sociotechnical collective and Binder et al. (2015) used the actor–network theory (ANT) methodology to unpack participants as networks of diverse entities.

In this paper, the ANT method is used to illuminate the role played by Web 2.0 technology in collaborative design projects undertaken by undergraduate engineering students. It uses ANT as a conceptual framework for exploring collective sociotechnical processes that privilege neither natural nor cultural accounts of scientific production asserting that science is a process of heterogeneous engineering in which the social, technical, conceptual, and textual are juxtaposed and translated. ANT advances relational materiality, which assumes that all entities achieve significance in relation to others. Therefore, ANT presents a coherent method for incorporating nonhumans into social scientific accounts (Sayes 2014). It is used in this paper to reflect on the role Web 2.0 can play in shaping how collaborative design is constituted and carried out in practice.

The ANT methodological toolkit is used to bring to debate the missing link (*masses*) in the collaborative design debate that is, the *nonhuman* elements as actors in the design process. Actors are endowed with agency and there is a need to describe their roles in the action and the tracing of social connections. When all these are considered, we get a detailed description of the actual contrivances at work that hold the network together while allowing an unbiased treatment of the actors. ANT allows the researcher to consider objects as real actors. The starting point is to explore the "uncertainties and controversies about who and what is acting when 'we' act" (Latour 2005, p. 45). This will allow a more comprehensive account of the interactions of human and nonhuman actors in making up the design process.

ANT is a unique methodological framework in its grounding in material relationalism or material semiotics which is expressed in its principle of general symmetry. It approaches the world as comprising heterogeneous relations and practices through which it treats humans and nonhumans alike as actors. Everything is an effect of relational practice. The focus of an ANT study is to trace the practices through which actors assemble a network in this case, it is the collaborative design network. The guideline is that in an ANT study, the researcher should mobilise a method that can trace the connections and the shifts in relations among the actors (Inkpen et al. 2007). This allows the researcher to map the topography of network connectivity and facilitate the identification of the roles played by the actors that interact in unique and constantly changing ways.

Literature review

An outline of ANT

ANT emerged in the mid-1980s through the work of John Law, Michel Callon, and Bruno Latour as a conceptual framework for exploring socio-technical processes (Minn 2016). According to Law (2007, p. 141), ANT is a set of material-semiotic tools, sensibilities, and methods of analysis that treat everything in the social and natural worlds as a continuously generated effect of myriad sets of relations among actors in a sociotechnical system. ANT assumes that nothing has reality or form outside the enactment of associations that link actors in the system. An ANT study therefore, should concentrate on exploring and characterising the associations and the practices that bring them out. Instead of it being a theory for explaining action, ANT is rather a philosophical position and a methodological framework "for inquiring into the real-world processes by which associations of humans and non-humans merge into a stable network or do not do so" (Atkinson 2000, p. 115). From the perspective of the STS researcher, we can view ANT as a descriptive tool that

allows researchers to understand better the complex patterns of interactions and relations among actors in a sociotechnical system. It is used to explain the state of affairs in reality compared to the desired result, describing the changes and effects within a translation process (Storni 2015).

ANT's perspective of socio-technical systems as dynamic networks of heterogeneous elements offers the potential for a richer understanding of Web 2.0 facilitated collaborative design as a network comprising diverse actors. According to ANT, the collaborative design process may be referred to as a network comprising a group of elements that interconnect and affect one another. As proposed by ANT, a system can be effectively studied if we look at all the elements, whether they are natural, technological, or human as interacting and active members of the sociotechnical network. We call networks sociotechnical because they connect human beings with nonhuman entities, such as knowledge and resources (Callon 1986). These elements are connected through a continuous mediation process that makes them converge on common problematisations, negotiate shared interests, engage in new roles and mobilise a critical mass of actors for collective projects (Bilodeau et al. 2019). Each element brings characteristics and repertoires but it is in the joint action within the network where it creates specific potential in the reality arising from the interaction of multiple actors.

Role of actors in a sociotechnical system

We refer to each of the elements that constitute a network as an actant; a part of the network that has some role to play. According to ANT, the term actant refers to any agent, collective or individual that can associate or disassociate with other agents. All actants are presumed to be equally important participants and they are valued by how they interact in the system. This is ANT's principle of *generalized symmetry* which suggests that all actants whether human or nonhuman should be combined into a single conceptual framework and assigned equal amounts of agency. We consider actants as indeterminate entities; they have no a priori substance or essence outside the network they associate. They drive their identity through the networks in which they associate. Actants enter networked associations which define them, name them and provide them with substance, action, intention, and subjectivity (Crawford 2005). Latour (2005), points out that actors are not substances, like pre-existing or delimited entities but events that cannot be separated from the relations established in the network. Each actant, whether human, technology or natural factor has an equal part to play in the system and must be considered as an equally important actor. Nonhumans are actors that are actively involved in networks and "not simply the hapless bearers of symbolic projection *(by human actors)*" (Latour 2005, p. 10). In a collaborative design project, nonhuman and human actors combine to form a hybrid design collective. Nonhuman actors take part in the design process through their actions (Rice 2018), they *mediate* human behaviour (Law and Mol 1995). They are part of the network building process of the collaborative design network through maintaining, strengthening or weakening alliances (Rice 2018). These nonhuman actors that affect, interfere or intervene with a human actor are what Latour (1992) calls objects 'with sociology'. These actants make a difference to produce social relations in 'group formations' that produce the connection of actors that constitute reality. However, without some human action, the element remains just an object; when the object comes into a relationship with a human, a new hybrid condition is formed.

There are two major types of actants, namely intermediaries and mediators. These actants make a difference to produce social relations in "group formations" that produce the connection of elements that fabricate reality. Mediators are actors that can displace other actors creating new connections that cause changes in the network's entities (Bilodeau and Potvin 2018). Intermediaries are entities that 'transport meaning or force without transformation' (Latour 2005, p. 39). In a collaborative design project, these may include inscriptions such as documents, working drawings, sketches, symbols (Callon 1991; Stoopendaal and Bal 2013) that circulate among the network's actors, stabilising agreements and making decisions sustainable. Depending on the details of the inscriptions provided, they might have the ability to displace human actors' viewpoints or could act as memory aids which support the setting up of collaborative work (Vinck 2012). As an intermediary, an object can replace a human action through substitution, Latour (1992) cites the example of how an automatic door-closer substitutes for human action. A nonhuman actor takes the place of a human and renders action by a human unnecessary or redundant. As a mediator, a nonhuman actor might interact with a human to facilitate an action, for example, a bench facilitates sitting. Nonhuman objects configure a new relationship with human actions. For instance, a mobile phone enables connection between humans but frames and structures that interaction, mediating between the two. We argue in this paper that nonhuman actors take part as mediators of human action most clearly in the form of tools (Rice 2018). Latour goes further in his definition, "What then, is a tool? The extension of social skills to nonhumans" (Latour 1999, p. 211).

However, this is not a simple task because as Latour (2005) argues the role played by actants is *overtaken*, agency is always derived from many interfering sources, rather than possessed by individuals (Latour 2005). The role played by actants is in fact partially existent, suggesting that the different roles played by actants come into existence in various ways and situations, unbounded by the designer's intention or methods (Andersen et al. 2015). In general terms, participation as partial and overtaken presents three challenges to design. Firstly, actants are not stand-alone subjects, but they are made up and configured as actor-networks. Secondly, the role played by actants is not limited to design activities per se or, predicated by physical presence or intentional interaction. Thirdly, there is no gold standard for a priori evaluation of the quality of the role played by an actant or even for distinguishing between playing a role or not playing a role (Andersen et al. 2015).

We can put the role played by nonhuman actors in the network into three categories namely; nonhuman actors *substituting* for humans, nonhuman actors *mediating* humans and nonhuman actors *communicating* with humans. The various modes and language of human communication during design conversation are clear, that is discussions, thoughts, dialogue, conversations and arguments. These can be easily transcribed through minutes, reports, diagrams, maps, models, sketches, agendas or other media (Lindstrom and Stahl 2012). However, the role played by nonhuman actors and the language they use is a moot point (Rice 2018). The role and language of nonhumans is less familiar, although it is imbricated in various ways in the sketches, reports and models mentioned above. Rice (2018) suggests that nonhuman actors' role in design conversations is *telling* human messages and information. Serres (1995) describes nonhuman actors as *'message-bearers'* that communicate across disparate domains and act as a *sign*. Nonhuman actors also play a part as the medium through which the design process is framed and developed, thus becoming part of the language in which the design conversation is held. ANT's idea of semiotics helps us to understand how nonhuman actors communicate with humans. In essence, design is a '*conversation*' (Lawson 2005). It is a conversation mainly between the members

of a design team and also between the team members and the media chosen to represent the design ideas (Rice 2018).

While both humans and nonhumans are actors in their own right, they cannot play a role if they do not act; no action means no role played. The role played as we understand action, is an effect of an actor on another actor (Rice 2018). Action can be carried out by anything that affects something else or the effect one actor has on another. Myriad actors ought to be considered equally for their various participatory actions. There is need to violate the boundaries and unnecessary dichotomies such that any design *action* is considered pertinent regardless of whether the actor is human or nonhuman (Rice 2018).

Methodology

Research design

This paper mobilises ANT resources to mount a methodological framework to understand the role played by Web 2.0 in the collaborative design process. Although ANT does not prescribe a rigid method (Fioravanti and Velho 2010), most ANT studies are grounded in empirical case studies. This study therefore, makes use of a case study of collaborative design teams from a department of Industrial and Manufacturing Engineering at a University of Technology in Zimbabwe. The participants were 31 undergraduate engineering students who were engaged in collaborative design projects in small groups of five students each.

Data-collection and analysis

Data were constituted using a mixture of data collection instruments including a questionnaire comprising closed and open-ended questions, semi-structured interview schedules, observation schedules, and nonparticipant observation of online activities by student designers. This mixture of data collection instruments was necessary because following actors in a complex and dynamic network like Web 2.0-facilitated collaborative requires the researcher to be well equipped. There was a need to follow the actors, tracing the role of Web 2.0 as an actor in the collaborative design process paying particular attention to the ever-changing associations that mirror the role played by Web 2.0 technology. When tracing the associations the point is to "follow the actors in their weaving through things they have added to social skills to render more durable the constantly shifting interactions" (Latour 2005, p. 68). Attention was paid to tracing the role played by Web 2.0 technology in making up the collaborative design process.

The ontological position of ANT that views practice as an assemblage of the heterogeneous entities in a network location (Latour 2005) was found to be important in analysing and interpreting the meaning of data in this study. The overall aim was to understand the role played by Web 2.0 in collaborative design and the implications for theory and practice. The focus was on identifying actors concerning how they take their form and gain some attributes because of their relations with other entities. This suggests that not all actors are discrete actors; most of them are in practice distributed across material and discursive processes. The role played by the actors is therefore, a result of the associations between entities. To understand the role played by actors, particular attention was given to reciprocal relations among everything that was involved in the collaborative design process. Besides,

this focus on the relationality of actors is consistent with one of the key methodological premise of ANT, namely the principle of generalised symmetry (Callon 1986; Vinck 2012) which considers both human and nonhuman elements as equal actors within a network. Therefore, we should use the same analytical and descriptive framework when faced with either a human or nonhuman actor that composes a network within an activity. The findings are discussed in the next section.

Research findings

This section presents the findings of the study. An ANT based study requires the researcher to identify the actors involved in an actor-network, describe their associations and the action network that they constitute. The findings of the study are therefore organised using these guidelines.

Actors in Web 2.0 facilitated collaborative design

Data shows that in addition to the conspicuous human actors, including students, their lecturers, technicians, and experts, other inconspicuous nonhuman actors took part in the design process. The enrolment of Web 2.0 technologies in the design process resulted in the engagement of a myriad of actors, including the material and social elements that were interwoven in the collaborative design process. Besides human actors, there were many other actors which included Web 2.0 tools that were enrolled in the design process. The Web 2.0 technologies included Facebook, WhatsApp, Viber, Skype, Gtalk, Email, MixIt, Twitter, LinkedIn, eText, Google+, and WeChat. Figure 1 shows a word cloud illustrating Web 2.0 technologies. The technologies in large print, namely Facebook and WhatsApp were the most conspicuous actors. Video Talk and Twitter were inconspicuous and the rest, for example, LinkedIn and Viber were sparingly involved.

Other inconspicuous actors include various mobile computing devices such as laptops, iPods, tablet computers and smartphones which were used to access the Internet from the university or private mobile network. When students were in places which were not covered by the university WiFi, they continued to work on the design project using Internet connectivity provided by private mobile network service providers. Another inconspicuous

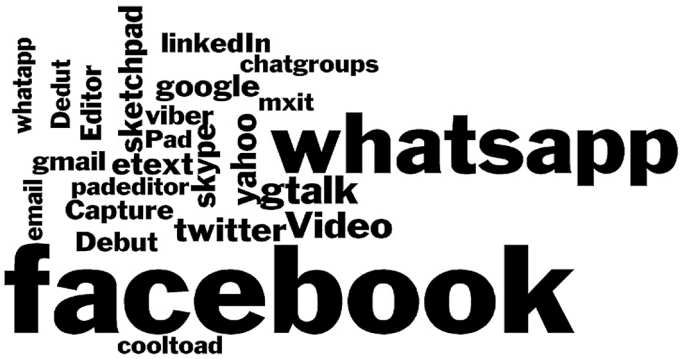

Fig. 1 Word cloud of Web 2.0 technologies used by student designers

actor was the students' competence or familiarity with Web 2.0 technologies which influenced their enrollment into the collaborative design network.

The widespread nature of Web 2.0 technology was critical for the enrollment of the technology into the design network. The students accessed the Web 2.0 platform through a multiplicity of computing devices including desktop computers, laptops, tablets, and smartphones. As a result of the proliferation of mobile computing devices, students had unlimited access to the design project and could make their contributions to the design project anytime and anywhere. However, the use of Web 2.0 technology was not without challenges. Students pointed out that Internet connectivity was slow during the day. That made it difficult for students to upload videos and files with graphics since these needed fast Internet connectivity. Although they had the choice of using mobile Internet connectivity, they considered that to be an expensive choice and many students could not afford to download bandwidth-hungry files such as videos. However, the challenge of expensive mobile Internet connectivity was eased when students used the choice of buying weekly or monthly Internet bundles dedicated to social network applications such as WhatsApp and Facebook.

Mapping the associations among actors in the collaborative design project

After identifying the actors, the next logical thing for this study was to trace the flows of associations and links that were formed among the actors as they constituted the collaborative design process. Data analysis shows that actors both human and nonhuman engaged one another in multiple ways as they tried to create a collective understanding of the design problem(s), design context and the whole design process. The ties among these heterogeneous elements influenced how collaborative design was carried out in practice. The various forms of connections formed from the communication links among actors allowed more flexible and adaptable interactions among students. A further dimension of these associations is that distance and time limitations did not bind them. That was because of the availability of mobile devices and widespread connectivity.

Another important finding is that 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 on this aspect is the ease with which actors could switch association from one actor to the next. For example, students were not tied to one tool but would move freely to different tools. Since collaborative design is a dynamic process that makes use of various tools to carry out various tasks, students needed to switch between tools and the functionality that they provide according to the demands of the situation. Internet connectivity shifted from Wi-Fi connectivity to mobile network connectivity, ensuring that the students were always online on a 24/7 basis. That allowed students to work on the design task anytime and from anywhere. WhatsApp camera, for example, made it easy for students to capture and share pictures that illustrated their ideas on the design problem and its solution as they came across them. Besides that, the Internet bundles, for example, Facebook bundles and WhatsApp bundles ensured that students remained connected anytime from anywhere. Figure 2 shows the relationships and ties created among actors in the collaborative design network at the Web 2.0 design working space.

The following excerpt from an interview with a spokesperson for one design team highlights Web 2.0 technologies which were used in the collaborative design and the ties created;

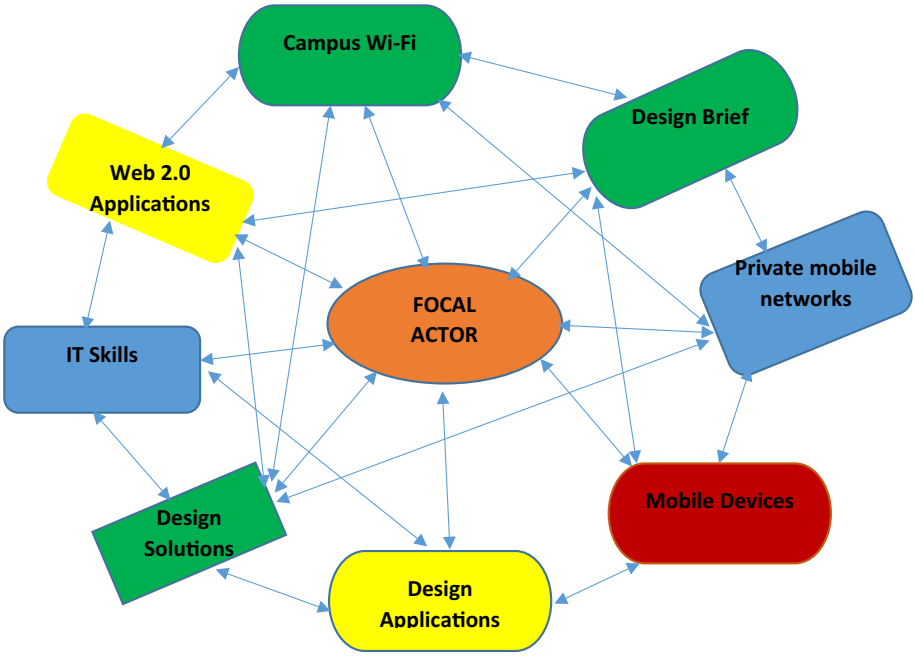

Fig. 2 Associations created among actors in the Web 2.0 facilitated collaborative design network

> Mostly I use… technology like Twitter, which I used to share to link with experts 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 see how they reach … where they are, items of their education, their experience, and their companies. Facebook, I normally use it for linking with classmates; they would incorporate me in their groups to share with them, people share, give their own opinions and Blog Spots. (Interview with a spokesperson for group B) (Chitanana 2016)

The affordance of Web 2.0 to support dialogue by documenting the conversation among students 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, 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 has some challenge there; he communicates with others; we have a group account for that. We contribute that make each one of us quickly decide on what we can do to proceed while alone without others. (Source: Interview with Spokesperson for Group C) Chitanana 2016)

Besides that, Web 2.0 technologies allowed widespread methods of data input through a variety of equipment, including personal computers, laptops, and smartphones. That allowed multiple forms of linkages among students. By giving students access to other

students' ideas in such a rich multimedia environment, Web 2.0 technology strengthened ties between students and the design problem. Web 2.0 technology strengthened network ties because of the ease with which students could use the technology. Its user-friendliness saw every student being able to use the technology to share ideas. That helped in strengthening the ties among actors in the collaborative design network. Students would find it difficult to take part in the collaborative design in the absence of Web 2.0 technology. For example, on several occasions, students would blame their failure to take part in discussions to the unavailability of the Internet.

The mediation role of Web 2.0 technology in collaborative design

This section presents the trails that illustrate the mediational role of Web 2.0 technology during the collaborative design process. The main argument put forward by this paper is that researchers of associations should treat all objects as mediators, as unpredictable and complex no matter how seemingly predictable they may appear at first. Data shows that Web 2.0 technology did not just act as the conduit for information transmission but mediated the translation of interests of the actors involved in the design project. Web 2.0 technologies mediated the way the students shared design ideas and information among themselves. They mediated the ways the students engaged with each other and shared design ideas through dialogue as they sought to understand the design problem. The students did not just take all the ideas presented on the platform but they could filter the information basing on the context most relevant to them. The ability to filter basing on what the students 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.

Furthermore, Web 2.0 technology-mediated the way the spokesperson of each group presented the design problem, helping other actors to build their thoughts about the design solution. The agreed interpretation of the design problem acted as the first obligatory passage point (OPP) which student designers needed to cross for the design process to start:

> … 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 it in public but it will help them. So, with that we thought it was a joke, we consulted the lecturer about that project and he was happy about it. That's how it started and now we are in it. (Interview with the Spokesperson for group C) (Chitanana 2016)

Thus, in ANT terms, Web 2.0 technology-mediated the translation of students' understanding of the design problem resulting in the alignment of their interests on which design solution to pursue. The agreed-upon design ideas were translated into design sketches and working drawings in the design studio. These forms of presentation of design ideas are called inscriptions. These were used to convey design ideas that were discussed and agreed upon by students. The circulation of these inscriptions through Web 2.0 technology allowed students to build common understanding of the design problem. They were never considered as the final product; even an attempt to black-box them in working drawings was unsuccessful in making them prescribe how the design artifact was created. Web 2.0 technologies made these inscriptions leaky boxes since students could reflect on them. The students we able to use new knowledge gained through interaction with other students and the experts engaged, to reconsider the inscriptions. More often than not, they changed their working drawings, with the effect of changing the course of the collaborative design process.

Box 1 Facebook posting October 17, 2013, at 5:41 via mobile (Chitanana 2016)

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

Box 2 Facebook posting, October 22, 2013 at 1:44 pm (Chitanana 2016)

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 1:44 p

The Web 2.0 working spaces were characterised by informal, spontaneous, and unplanned interaction among students that kept them connected 24/7. Although most conversations were scheduled in advance by the spokesperson, some were spontaneous and unintended. More often than not, students found themselves in some unplanned conversations that helped to shape how the design process was constituted. Even the planned conversations ended up with students engaging in unplanned discussions which led to major decisions on how the design process proceeded. From time to time, students would call the attention of colleagues to some aspect of the design problem, drawing attention to something they would have overlooked during previous discussions (See Box 1, for an example of such conversations).

Such dialogues forced students to revisit certain decisions that they had made with the effect of changing the course of the design process. Such spontaneous conversation reflect the highly contingent character of Web 2.0 facilitated collaborative design process as it unfolds. These conversations helped student design teams to correct mistakes rapidly because of the iterative, non-sequential approach.

In addition to this, Web 2.0 technology platform created a flat design environment in which students were free to discuss various issues as they wished. The students took advantage of these affordances of Web 2.0 to engage in opportunistic conversations to discuss various issues that at first sight seemed irrelevant to the design project. These conversations were important for dealing with relevant but hidden issues affecting relationships among the students. Although not directly relevant to the design task at hand, these helped to strengthen ties among student designers and created a collegial environment conducive to design creativity. Box 2 shows examples of such conversations and seemingly irrelevant information shared by student designers during the design process.

As the foregoing example shows, the discussions that unfold in Web 2.0 forums were raised not only by scientific and technical aspects of the design process but also by social concerns of the students. However, although such conversations are largely viewed as counterproductive, the analysis shows that they also had a positive role to play. Such opportunistic conversations provided lighter moments that students 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 the students to get to know more about other students' state of mind during the design process. Such conversations promoted transparency of process and

progress which established strong ties among students. It was therefore, evident that actors did not necessarily plan what to do but rather matters of concern that came for discussion emerged in the very making of them. Therefore, boundaries of roles and participation were always at stake as new maters of concern arose.

A more interesting observation was that in most cases, Web 2.0 technology acted as the 'spokesperson', of the design team. The technology exerted its agency in such a way that it established itself as the spokesperson of the design network. Web 2.0 technologies such as Facebook, for example, would send regularly 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 influence their allies in the network to accept and develop the agreed-upon design solution. By so doing, Web 2.0 technology complemented efforts by the human spokespersons who used various influential strategies that enticed other actors to join and take part in the collaborative design process. This shows that Web 2.0 complemented the efforts of human spokespersons to keep the network together. Where the human spokesperson lost its voice and persuasive power, Web 2.0 technology worked to keep the network going. For example, when some actors left the network or became inactive for a long period, Facebook would send updates on the conversations taking place on the forum through email. By so doing, Facebook enrolled other actors 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. Because of these messages, perhaps Facebook 'spoke' on behalf of the group, hence, Web 2.0 technology could establish itself as an indispensable actor in the collaborative design network.

Discussion

Primarily, the findings of this study show that Web 2.0 facilitated collaborative design progresses through dialogue, from which the final design artifact emerges. Web 2.0 design spaces provided a tool for the design teams to discuss and develop the requirements for the design. In translating students' 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 necessary for the alignment of diverse ideas thus making them able to agree on one design solution. They further refined it to provide a satisfying design solution. The non-linear and non-sequential nature of the Web 2.0-mediated collaborative design process allowed students to revisit their decisions and make corrections to the design solution easily. Web 2.0 thus mediated the translation of ideas into design artifacts. This was a result of the ease with which Web 2.0 allowed students to put across their point of view, which gave them the power to influence the design network connectivity properties. The effortless communication meant that students could interact with each other quickly and easily without requiring a lot of formal or technical setup. The ability of students to communicate in both synchronously and asynchronously modes made a difference during the design process. That took place regardless of distance and time differences among actors.

The findings of the study show that Web 2.0 technology stirred the collaborative design process by stimulating unpredictable actions, thus actively contributing to the shaping of the emerging collaborative design network. Therefore, Web 2.0 technologies should not be viewed as simple tools for communication as described in some of the

literature available but as non-human actors which can mediate the collaborative design process and shape the way it is constituted. The mediation role of Web 2.0 technology was assumed because of a shift in the links among actors from "a provisionally less reliable one to a longer-lasting, more faithful one" (Latour 1988, 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. Since the action was by stimulation, in most cases, the consequences would not be clear but were unintended because the actors were stimulated, as they reacted to the stimulus not as always expected. More often than not, the students used Web 2.0 in unforeseen ways that resulted in unforeseen influences on their actions. Therefore, the agency was not limited to students as individuals, objects or social determinants but as an emerging effect of the interactions of network components.

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 a relationship with another actor, they translate the original programmes of action for both into a new one. This complicates the role played by Web 2.0 technology. To prove 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 Web 2.0 technology used would sometimes resist their actions, causing them to change their plans of action. In most cases, the interaction between students and the Web 2.0 technology resulted in unexpected actions. This illuminates the ambiguities and contingencies of relationality as a resource for collaborative design (Gaver et al. 2003), which calls for the ability among designers to deal with unexpected situations that may arise during the design process.

A major finding from this study is that Web 2.0 technologies assumed the role of the spokesperson for the design network (Chitanana 2016). They spoke on behalf of the network. This challenges existing literature which favours a human actor for the role of spokesperson. The results show that the role of a 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. A network requires a legitimate and credible spokesperson to represent it and speak on its behalf (Bilodeau et al. 2019). The credibility and legitimacy of Web 2.0 as spokespersons is based on their availability 24/7 and the value that the human actors place on the information they convey. 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. As a spokesperson for the design team, Web 2.0 technology was actively involved in network building by interessing and enrolling more actors into the design team. Web 2.0 technology circulated interessement devices such as sketches, pictures, and videos, which inspired some human actors to support the collaborative design process. In an actor-network, the spokesperson assembles various entities known as intermediaries which contribute to their representations. Unlike human spokespersons which can change goals (Hodgkinson and Starbuck 2008) and are emotionally laden (Liu and Maitlis 2014), nonhuman spokespersons are best placed to hold the network together since they are consistent in their presence. Without such material durability, the design process would be fragile, unstable and solely depend on capabilities and sometimes undependable human actors (van den Broek and Rieple 2017). As Czarniawska (2006, p. 1554) notes, when: "It is to point out the special role that objects play in associations: they stabilize."

Conclusions

The findings of this study demonstrate that Web 2.0 technologies were able to play their role not only as carriers of information but as entities that mediated action among students. These technologies mediated the overall collaborative design experience and helped students to develop a deeper sense of collaboration during the design process. Since Web 2.0 technologies mediated action by motivating students to act in unpredictable ways, Web 2.0 technologies could be considered as action stimulants that actively contributed to shaping how the collaborative design process was constituted and carried out in practice. 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 designers can arrive at novel and sometimes unexpected solutions. The transparent multimedia based dialogue afforded by Web 2.0 technologies helped in the alignment of interests, leading to shared meaning-making among students.

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