ARE SOCIAL NETWORK SITES THE FUTURE OF ENGINEERING DESIGN EDUCATION?

Ross BRISCO, Robert WHITFIELD and Hilary GRIERSON
Department of Design, Manufacture and Engineering Management, University of Strathclyde, Glasgow

ABSTRACT
This paper presents how online social network sites (SNSs) are being used by students in distributed engineering design teams to support design activities; and its implications for the future of design education. Ethnographic studies of a Global Design Project (GDP) were conducted from 2015-2017 to collect information on the growing use of SNSs by students. Team diaries were kept, systematically recording observations, and students reported their personal experiences in reports. Nvivo 11 was utilised to code data and make conclusions on team's collaborative behaviour, and their successes and failures with the technologies used. This study has revealed that students of the GDP have made a change in the way they collaborate by means of SNSs. Evidence shows that students are able to utilise the functionality of SNSs to support the design process, design activities and design thinking. The growth of SNSs within academia and industry suggest that students will need to utilise the technology or at least the functionalities of SNSs in the future. It is important to question how future engineering design education might be delivered and how social network site functionality can be best used.

Keywords: Social network site, collaborative design, engineering design, project-based learning

1   INTRODUCTION
Social network sites (SNSs) allow users to co-operate, co-ordinate, communicate and collaborate. Boyd and Ellison, [1] note a social network site should meet three functions; "(1) construct a public or semi-public profile within a bounded system, (2) articulate a list of other users with whom they share a connection, and (3) view and traverse their list of connections and those made by others within the system". Cross [2] suggests an alternative view to; "enable people to connect or network with one another through the use of profile pages". Both are valid and include the functionality of many websites, such as: Facebook, Instagram, Twitter, Snapchat, WhatsApp and Slack [3]. In general, SNSs are a technology which enables greater connectedness, socially and within teamwork. The technology has the potential to facilitate a perpetual connection between users to share ideas and make decisions.

Participants in the Global Design Project (GDP), a product design class jointly organised by the University of Strathclyde, City of London University and the University of Malta, have successfully utilised SNSs and other Computer-Supported Collaborative Design (CSCD) technologies for several years of the project to facilitate the distributed design process. What follows are findings from three years of the GDP and a discussion on the challenges which might arise when the next generation of university students expect to use the same ubiquitous technologies they currently use for socialising.

In engineering design, two distinct theories have emerged in student learning, the behavioural model and the constructionist model [4]. The difference between the two is the fundamental assumption about how people learn. The behavioural model notes knowledge can be transferred from the teacher to the student through lectures and presentations or through mediums such as books. Whereas the constructionist model takes the view that knowledge is not transferred but is created by the learner through education, in the case of project-based learning, through experiencing [5]. Project-based learning supports engineering design education well because of the nature of design projects; support for building skills [6] and learning by experiencing the design process [7]. As a result, there has been a clear change in the implementation of engineering education towards a constructionist model [4].

Studio-based design and design projects introduce learning through problem solving and experience. Ala et al. [6] present the results of the change in delivered classes from lecture-based to project-based

learning. They confirm that student opinions of the classes improved after the change to project-based learning from 35% to 77% approval rate. Unfortunately, outside of opinion surveys, it is difficult to quantify the effects of implementing project-based learning principles. Chen et al. [8] report on the use of a project-based approach to engineering design education and the integration of computer technology to support projects claiming improvements in students understanding of the design process because of improved reflection on the learning process and design outputs.

In recent years, the use of SNSs in engineering design education has demonstrated promise in creating a supportive environment if students are educated on how to use them [9]. The adoption of SNSs cannot be endorsed until the impact of the use of SNS on student learning is understood and defined. As defined by Beetham and Sharpe, [10] "Teachers who are excited about these technologies are often accused of using them regardless of whether or not they are pedagogically effective, and even in ignorance of the long tradition or pedagogical evidence thought". This creates a dilemma when students request the use of potentially better tools to support their learning, or when they choose to use them in disregard of the lecturer's request. Beetham and Sharpe, [10] continue: "in rethinking pedagogy for an age of digital information and communication, then, we are not trying to define some new aspect or area of the discipline: we are trying to re-articulate the entire discipline in this new context". This paper investigates how the use of SNSs can support project-based learning in student engineering design teams and how might educators support students better in future project work.

2   RESEARCH METHODOLOGY

In the studies of the GDP, students were asked to collaborate on the development of a product and utilise technology to support the distributed design process. They were asked to report on their experience of group work in reflective reports, giving evidence to support their use of technology. In addition, observations were made by the author on the way students chose to conduct their projects. The observations were kept systematically at weekly team meetings and were categorised to draw conclusions from a range of different team experiences over three years. A coding scheme, developed within Nvivo 11 by the lead author, to search for examples in students' project work.

3   FINDINGS

This section will present how SNSs are used by students to facilitate collaborative design; why they are used and what they can offer; from observations made in class and students reflective reports.

3.1 How students use SNS to facilitate a collaborative design process

SNSs come in many forms, and functionality differs slightly depending on the SNS platform. What they all afford teams is the ability to communicate within a private space: facilitating discussion, sharing, decision making, organisation and awareness amongst other abilities.

In the GDP 2015-2017, all students utilised a private group, private chat, or both, on SNSs. In the case of both, students utilise the private group to post project updates such as photos of design progress, documents, including decisions made and reminders of upcoming meetings. Private chats are used for quick messages to confirm information; or when prompt responses are required; and for pre-video conference meetings to confirm attendance. Private groups are utilised more asynchronously and private chats synchronously. Groups offer a multi-threaded interface allowing multiple discussions and responses to take place, whereas chats tend to be one-to-one to avoid confusion. Facebook offers this functionality in the form of groups and messenger. Team members add each other on Facebook as 'friends' and create private groups and messenger group chats with all team members. But this also allows students to see each other's social posts and personal photographs on the Facebook platform building social relationships. Some team members opt to use WhatsApp in place of Facebook messenger as this was more prevalent within team members. Some teams chose to use Slack, a mix of private SNS and team management, which offers tagging and searching functionality. In addition to SNSs, students utilised video-conference and cloud storage technologies to facilitate their projects.

The teams' experience is typically different to that of a collocated '*design studio*' style project due to the use of technology and the distributed nature of the design process. Rather than all team members engaging in a creative task, a small collocated group might conduct this type of activity and others would give their opinions. One team member shared their experience of collaborating online during the research stage: "*A number of research topics were devised and split up between team members ... This meant that each topic was covered by multiple people, but everybody carried out their research*

separately and discussed it in Facebook posts. Therefore, there was little interdependence for this stage. Although this was the stage where most discussion was needed so the wealth of research could be narrowed down into a distinct problem area to focus on". This was beneficial for some team dynamics as students more experienced in the design process could contribute their ideas and less experienced members could learn about design and offer their knowledge. However, as work was split between the team members there may have been missed opportunities for collaborative development.

SNS offered functionality which supported the team throughout the design process. One team member remarked: *"There were significantly less Facebook posts (during the prototyping stage) than the other stages. The end of the project was approaching meaning everyone was already clear on what had to be done and what tasks they were doing. In previous stages, Facebook posts were used for discussion of ideas and summaries of meetings/task allocation. It may also have been because prototype discussion and information exchange required more visual and instant communication than a Facebook group"*. As the team had a clear objective and the device was a simple form, prototyping did not require much formal input from other team members. Instead the team utilised a WhatsApp chat to share photos and receive feedback in an agile way for rapid development.

3.2 Why students choose SNS to facilitate a collaborative design process

At the beginning of the GDP teams were encouraged to experiment with collaborative platforms and decide which is best for their team. Most teams did this during their first video-conference meeting. Students chose SNS for many reasons including practicalities; students require a centralised place to store data; discuss options and make decisions. SNS supports students through a multitude of media and for no financial cost as reported by one student: *"We can share various information such as documents, picture, video, web links, technical files and zip folder without any expense"*. But importantly what makes SNS different from other platforms is its multi-threaded conversation functionality as reported by another student: *"For example, a team might be discussing scheduling deliverables for the prototyping stage, while concurrently discussing a specific prototyping task such as rough prototyping in another thread ... A single stream of conversation can quickly become confusing as different tasks are discussed"*. Multiple threads support modern teams with multiple sub teams. Tools such as forums offer this functionality and teams have used this technology in the past. SNSs go beyond the capabilities of forums in terms of functionality and awareness.

SNSs are highly popular for social communication. Facebook is the world's most popular social network site with 2.13 billion monthly active users for December 2017 [11]. Because of the popularity and pervasiveness of Facebook, most students of the GDP actively use a Facebook account everyday as reported by one student: *"Facebook is a simple channel for all members of the team to apply with working because everyone has a Facebook account and use it in normal life"*. Students who engage in Facebook are notified almost instantaneously for quick and prompt updates on academic work. Students do not need to put aside project working time but can be actively engaging at any time of the day, from any location, through a mobile device. Downtime whilst waiting in line at a coffee shop or whilst using public transport becomes a potential for work time. The opportunity of this time is great, but the quality of work time is unknown. There is also the issue of overworking. Students cannot be expected to work 24/7 and so boundaries and sensible expectations need to be established.

Occasions arise where all team members do not actively engage with a common SNS platform and this leads to an exploration of less popular platforms. Google Hangouts has been one solution which integrates well with other Google products and students often have a Google account and already have many Google apps on their Android phones which keep them connected and aware of updates. One student reported: *"Although the medium for asynchronous communication was chosen as Facebook group, a discrepancy observed in the same was that every member had to be continuously connected online to view the latest updates, participate in the design discussion and be informed about the future meeting schedules"*. This relates to the idea of familiarity with a platform. Students can utilise tools faster and to a higher quality if they have used them in the past [10]. Then, it makes sense for students to utilise familiar technologies rather than to begin to learn a new technology within the time frame of a project. This was confirmed by a student in their reflective report choosing to use SNSs: *"due to the easy accessibility of these tools for university students as well as being familiar with them, also trying new tools would be timely and for this project we did not have a lot of time"*. Teams typically spend the first 2 weeks of the project discussing teamwork factors such as their choice of technology and assigning roles. Exploratory time is essential to build relationships contributing towards trust, and to

learn about each other's skills and interests. Students are supplied with email contact information at the start of their GDPs as this is the easiest way for class organisation. However, most students quickly move from email to other platforms. One student reported the content of the initial email and the benefit of background information. *"It was agreed that the email should include personal background, such as country of origin, what was studied previously or what was being studied at the moment of the assignment, music taste, Facebook and Skype information ... this gave the team members background information, so they were able to relate to each other in a more personal level"*. It would be the recommendation of the author that where possible teams spend more time building a relationship, as students do not focus enough on social aspects before rushing into the design aspects.

3.3 What SNS can offer the facilitation of the collaborative design process

SNS offers a semi-synchronous experience like other text-based communication methods, for example email or instant messenger. Meaning a message may be responded to immediately (synchronously) or delayed (asynchronously). This suits users who require their tools to be agile. Communication over SNS all contributed to discussion, negotiation and ultimately decision making during the design process. One student remarked: *"The advantages that Facebook had over the other methods were its availability to everyone and the ability to 'comment' on any file that had been uploaded. The ability to comment on sketches throughout the process was extremely useful to promote the necessary discussion surrounding a particular idea"*. Artefacts uploaded to SNSs act as a topic of discussion and a location to host the discussion. When a decision is made this location acts as the '*informer*' for all team members. When it is difficult to come to a consensus SNSs offer voting mechanisms. Teams utilised voting for agreement e.g. on concept selection but also to ensure all agreed on the design process, e.g. deciding between two design methods. However, it is important to note that students tend to share too much information and some team members felt overwhelmed with information. When this occurred, video-conference was a crucial tool in alleviating confusion and clarifying information and decisions.

All team members who are connected to the same SNS platform will be notified and updated of changes. Commonly this comes in the form of notifications. Notifications can be: new information, person-related (where a person is linked with a post) or topic-related (where a common thread links the messages). The SNS and project management software, Slack, uses notifications and tagging for awareness and searching. Different tags can be related to different concepts, stages in the process, design methods, sub-teams etc. This encourages conversations as it prompts team members for a response and ensures all team members are up-to-date with the latest information avoiding confusion and rework. Another useful awareness feature determines if a message has been read or not. Tension can result in teams when it takes a while to receive a response. This functionality contributes towards alleviating this, as reported by one student: *"Facebook, WhatsApp and some other social networks have overcome this problem (ambiguity in silence), by allowing you to see if the person has seen your message with an indicator next to the message. If they have seen it and not responded in what you deem to be a reasonable time it allows you to follow up with them. While a small feature it is a significant one because without it much time is wasted sending unnecessary follow up mails on Slack"*. Trust can be built in many ways but takes time [10]. One team reported that almost half of all their communications on SNSs were social in nature and not related to project work. This same team also reported high levels of trust for all team members in a class survey. When communication broke down with distributed team members it contributed to low levels of trust.

4   DISCUSSION

The following section takes the lessons learnt from the experiences in the GDP over the past three years and introduces the challenges which can be faced in implementing the use of SNSs.

The GDP offered students the experience of multi-discipline design projects and managing design in a distributed environment. SNS is the tool of choice for current students due to its general popularity. However, we should question the suitability of this technology and the preparation of students for future employment. Should academics create an environment to experience a real design project by starting up their own business, discovering a problem, solving it and producing a product to meet the market need? Within the bounds of our academic structures it may not be feasible, but could educators push for a more augmented experience. The functionality of SNS could enable more advanced project work allowing students to connect with experienced designers and manufacturers who wish to work with students to develop their ideas and offer advice. Students benefit from the experience of working

with industry and industry partners can benefit from the ideas which students contribute to the design process. SNS might also assist in finding these partners and managing the process.

Within the GDP, students are graded based on the quality of their presentations, the outcomes of their projects and a reflective report which details their experience based on a topic (e.g. use of CAD within the project, leadership, cultural aspects etc). However, this may not be the best way to grade students. Should educators put emphasis on grading the softer skills involved within the project such as contribution towards design activities or ability to communicate? If all work is conducted digitally then the contribution of each team member is also recorded.

Designers utilise design methods to advance the progress of a project. Within the GDP, there were a few design methods which lent themselves to the distributed design process. The ability to discuss ideas enables problem-solving and ideation tasks, as well as asynchronous communication enabling reflection. 6-3-5 is a method often used by students of the GDP. It asks a group of six student to develop three rough ideas in five minutes and draw them. The sketches are then passed onto the next member of the team who develops the idea for five further minutes and so on. Teams utilise SNS functionality to transfer these sketches to each other and tag each other so they are aware of work which needs to be completed, and there is potential to automate this process. When unstructured approaches were attempted in the GDP they tend to require a leader who is experienced in the technique, to instruct. Structured methods tend to organise themselves reducing organisational issues.

At the ICED conference 2017, a joint workshop was held between the Collaborative Design SIG and Design Education SIG. The workshop asked participants to share their teaching and learning experiences and discuss the future of engineering design education. Many themes were raised on the general topic of collaborative design education, and some related to the topic of SNSs. One common theme of discussion was the part that formal and informal learning technologies can and should play in the future of engineering design education.

Within distributed projects, the human relationship is often forgotten. It is a human-computer reaction that the person is talking with a machine rather than another human being [12]. The ICED workshop identified that this is helped with regular video-conference meetings where trust could be built between team members and conflicts could be negotiated and settled. SNS can support this, as the user is not represented by identifying text such as their name or email address, but by their profile and most importantly their picture; offering background information on team members and a more personal experience. Students of the GDP often remark that within the short amount of time available for the projects they don't have the ability to build meaningful relationships. SNS may not offer the same immersive or pervasive experience as an in-person face-to-face meeting or a video-conference, but a longer sustained relationship on an asynchronous platform can offer a sense of presence [13].

Another issue was in the delivery of information from mentors to students. The GDP assign mentors to offer advice when problems arise. However, mentors all come from different backgrounds, are located at different institutions, and have different interests. Each team may not be receiving the same level or quality of knowledge to develop their projects. A holistic approach to mentoring where all involved with the project can contribute could solve this if managed properly. If mentors communicated with students on an academic or project-based SNS platform, in a controlled environment, they might also benefit from the spontaneous prompt and quick nature of the interactions. The mentor with the appropriate expertise could engage with students and all would be more closely connected.

It's sometimes difficult to implement new ideas and technologies into the educational process due to institutional regulations and procedures as identified by participants of the ICED workshop. Educators who dare to test new technologies can be criticised for not fully understanding the technology and how it might impact the learning experience [10]. However, until it is tried it cannot be known for certain. At the University of Strathclyde, staff are encouraged to attend lectures on the latest teaching methods including the use of 'University approved technology'. Although engaging with students on SNSs like Facebook is discouraged by the University on professionalism and privacy grounds, other platforms such as Twiducate and Edmondo are encouraged as a safe 'walled garden' environment. Learning systems such as Moodle and Blackboard are becoming better tools with more engaging environments through development and plugins, which would benefit from more SNS inspired functionality. However, this might only be achievable if educators and students demand this functionality and trigger a greater understanding of how the technologies used can impact the learning environment. Perhaps a bottom-up approach might offer a more agile and engaging learning environment for students where the requirement to support students remain fixed, but the technologies can change over time. The next

steps for this research are to develop a method of systematically investigating students' use of technology, particularly SNSs, to understand if it meets a set of collaborative requirements. The work done in this study, [3] and [14] will contribute towards greater understanding of the requirements.

5   CONCLUSION

SNSs have been successfully utilised by students of the GDP for three years. Students have demonstrated their use of SNSs to facilitate communication, co-ordination and collaboration during design projects. The technology supports students with design activities and decision making throughout the design process. SNSs offer the necessary functionality to facilitate team collaboration and promotes informal information sharing, the building of trust between team members, awareness of other team members work and reflection. However, this can only be achieved if all team members commit to the shared platform and share relevant information with each other.

In education, it is difficult to switch from existing teaching methods to using new technologies. There might be considerable benefits from using new technologies such as SNSs in a learning environment but there are also barriers. For engineering design, sharing of information and artefacts; and facilitating of distributed design activities have the potential to benefit from the use of SNSs in the design process; but there is a lack of research and few quantitative ways to measure its impact.

In the future, it can be expected that students will continue to request the use of new technologies and we can expect an increase in their use in industry. However, if researchers are not experimenting and investigating the impact of utilising SNSs during design projects, their impact will remain unknown.

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