Sensing-Bot and Persuasive Systems for the New Makerspace

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Abstract. The Makerspace fabrication platform is finding traction in academic institutions of all sorts including engineering, art, and design schools. With a reliance on automated technologies, social learning and teaching time is reduced for the user of computer aided manufacturing (CAM) devices. Often, usage of such tools requires proper attire and protective wear but it is confusing to know when and which protective wear to use. Furthermore, when using toxic chemicals, everyone in the proximity is exposed and at risk of becoming sensitized and having an immediate bad health reaction. In the future there will have to be systems in place that streamline adherence to safety procedures. To foment a creative space and encourage the user's pleasure in the fabrication process, persuasive systems of influence will be essential to encourage healthy behavior. Sensing technology paired with socially influencing systems will facilitate safety in the new Makerspace.

Keywords: sensing-bot, makerspace, computer aided manufacturing

1 Introduction

The affordability of rapid prototyping equipment has spawned an increase in availability and access to high end fabrication workshops, with the trade-off of having reduced skillset requirements for the users. The functions of wood shops, metal shops, hobby shops and art studios are now finding a recombined shared platform in the phenomenon known as the Makerspace. Somewhat of a trending international occurrence, the Makerspace platform is finding traction in academic institutions of all sorts including engineering, art, and design schools.

As a site for tinkering and experimenting in manufacturing, the Makerspace differs from previous models of workshops in that these environments rely heavily on modes of computer aided manufacturing (CAM) technologies that require less and less frontend skillsets from the users (mostly students). One single 2 hour session with a 3D printing "MakerBot" is enough to provide almost any user with enough information to engage in a multitude of applications of the equipment. Similarly, a "ShopBot" can do the job of the router, the hand chisel, chop-saw, awl, grinder, planer and many more tools all at once. With this reliance on automated technologies, social learning and teaching is reduced for the user of CAM devices. The user needs not know the history, cultural tradition, and spectrum of physical hazards accompanying woodwork learned with years of spent learning the craft of carpentry, so to speak. The Makerspace user can bypass directly to a push-and-play mode of producing sophisticated objects and prototypes. Lost in this transaction with CAM technology is the sense of social interaction that was inherently embedded in previous systems of apprenticeship and tiered craftsman career paths.

The Makerspace is inherently a space for amateurish engagement in fabrication. There will be less trained professionals in these spaces to educate and oversee the milieu activities of material experimentation and production that until today have been heavily regulated by governmental agencies such as OSHA. Despite the appearance of CAM technologies not only in academic spaces but in manufacturing space around the United States, workplace health and safety conditions have not demonstrated significant changes in quality.

2 Health in the workplace

There are many difficulties in getting users to read Safety Data Sheets and act appropriately when using toxic chemicals such as solvents, aerosols, cleansers, etc. Often, usage of such tools requires proper attire and protective wear but it is confusing to know when and which protective wear to use. Furthermore, when using toxic chemicals, everyone in the proximity is exposed and at risk of becoming sensitized and having an immediate bad health reaction. Also, it is very hard to measure prolonged exposure rates to hazardous toxins. CAM devices still provide significant risks to the user. Paul Leigh published a holistic and cutting edge articled on the cost of labor related injuries in the Milbank Quarterly and the Economic Policy Institute an inclusive and cutting edge research[1]. The paper makes a claim that the reason costs of occupational related injury and illnesses are so high is a result of the combined sum of the costs included in treating cancer and many other related conditions [4]. Paid time-off, medical leave, lost production are all associated costs occurring in tandem to workplace injury. The sooner we can implement preventive measures for reducing work related injuries the sooner these costs will be reduced.

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[1] "Occupational injuries and illnesses are overlooked contributors to the overall national costs of all diseases, injuries, and deaths… estimates costs are roughly $250 billion a year. This amount exceeds the costs of several other diseases, including cancer, diabetes, and chronic obstructive pulmonary disease (COPD) for the same year [2013]. Rosamond and colleagues have estimated the total cost of all cancers, including medical costs and lost production, to be $219 billion in 2007, $31 billion less than the combined cost of occupational injury and illness. Yet by most accounts, the research, medical, policy and even public attention afforded either cancer, diabetes, or COPD far exceeds the attention given to occupational injuries and illnesses."

3 Understanding the Problem

In early 2015, in the research institute where this research project was conducted, a particular shop dedicated to rapid prototyping and artifact fabrication using mainly CAD and CAM technology saw two students endure cases of exposure based sensitization. This medical condition is categorized as the action or process of become hypersensitive to a particular chemical or compound through repeated or excessive contact. It is manifested as a severe allergic reaction requiring immediate medical attention. Once the subject becomes sensitized it is very likely that the most minimal reencounter with the culprit chemical with trigger the severe allergic reaction again. In other words, it is essential that the two students who suffered through this incident at the mentioned shop do not expose themselves again. Unless there is a method for communicating to the affected students what chemical compounds are in the shop over time, their options to work again in the shop are nearly none. Similarly, if all the users of the shop were aware of the discreet chemistry in the air of the shop their chances of becoming sensitized would also be greatly reduced.

The following are common habits that were observed in the shop over a period of time twice a week from September 2015 to November 2015:
lack of general awareness of hidden dangers of hazardous materials; misuse of protective gear and attire; underused Safety Data Sheets for Materials (Safety Data Sheets are commanded by OSHA to be linked to every type of material found in fabrication shops explain the hazards in such materials and often exist only in online repositories removed from the immediate space of fabrication).

There are various types of student fabricators in Makerspaces: architects, fabricators, machinists, prototypers, artists. Currently for these groups, proper usage of adequate protective gear is hard to supervise. The operation of CAM technology without heeding safety protocols is inherently dangerous, especially for these types of inexperienced fabricators.

In the future there will have to be systems in place that streamline adherence to safety procedures. To foment a creative space and encourage the user's pleasure in the fabrication process, persuasive systems of influence will be essential to encourage healthy behavior instead of heavy handed coercive systems [5]. When speaking of the future of persuasive technology systems, Csikszentmihalyi and Chatterjee recommend embedding in the discourse a sense of empowerment [1, 2]. This is extremely true for the young populations that work in Makerspaces because they are not to be scared away from experimenting at such a developmental stage in their education. Because Makerspaces present a good model for how trends in technology are to affect fabrication and manufacturing enterprises in the future it is in this type of space that this research and intervention seeks to make an impact. The hope is that presented methods of persuasive technologies tested in the Makerspace discussed in this paper will present scalable tactics to improve healthy behavior and safety awareness for the users of these type of fabrication spaces in general.

4 Sensor Technologies and Socially Influencing Systems

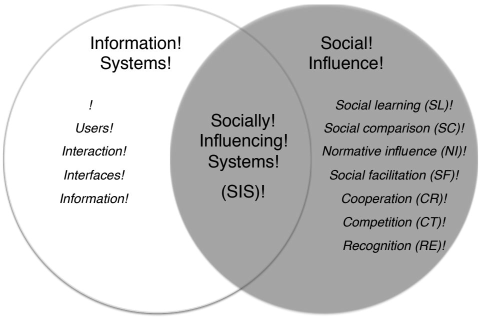

Fig. 1. Socially Influencing Systems [5]

This research project will produce an intervention that makes use of persuasive systems (Fig. 1) that will:

1 -Empower the user to engage with inherently hazardous materials safely: Visualization based technology to measure (through sensors) the toxicity of the environment can help everyone in the shop be on the same page is key.

2 –Clarify which proper protective gear, attire, safety procedures to follow and when. Here, aided with technology based cues (alarms), people will look around and inform each other about healthy behavior when they see someone carrying on in an unsafe manner.

3 –Provide better measuring of prolonged exposure rates to toxins. This is a skill that is very hard for a user to engage with amidst day-to-day activities inside the makerspace. Hence the intervention will use sensors to create data displays that explain a story of overall airborne toxins and loud noises present in the shop over the course of the week, month and year (Fig. 2).

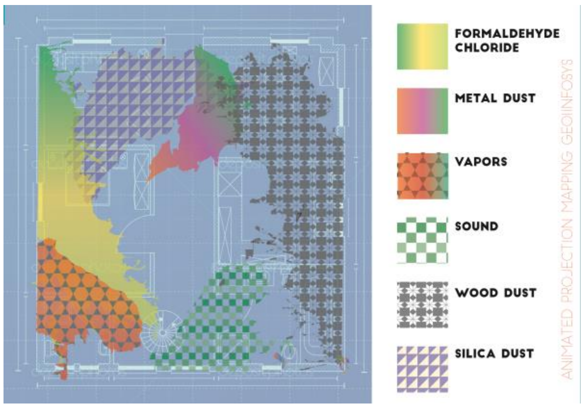

Fig. 2. Sample Geographic Information Display localized to a makerspace visualizing the presents of toxins in the air.

Fig. 3. Monitor displaying layout of chemicals inside a Makerspace over time. The monitor is situated outside the shop to influence the users of the space before they enter.

5 Designing a New Intervention Based on Similar Projects

The intervention in this research project will make use of novel and inexpensive ways of measuring indoor air quality. A few dollars' worth each, new sensor technology can be calibrated to pick up specific groups of chemicals in the air via Bluetooth, transmitting live results for rapid visualization. New sensors can transmit information on hazardous chemicals to a smartphone. Dr. Timothy Manning Swager created tiny sensors that detect chemical weapons and explosives (Fig. 4). But he also sees the potential for the technology to be used in a civilian application: smart food packaging. Dr. Swager, John D. MacArthur Professor of Chemistry at the Massachusetts Institute of Technology, has altered the chemistry in the sensors to detect a myriad of possible compounds.

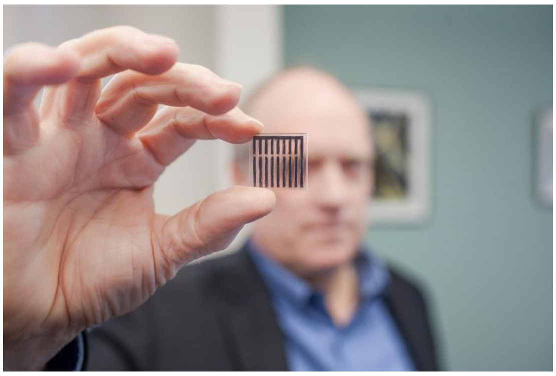

Fig. 4. Carbon nanotube mini-sensors developed at MIT.

These sensors can be mounted to a specifically designed device that circulates the shop simultaneously reading air quality much in the same way that a Roomba circulates the floor-space of an apartment. The device will change color according to the type of chemical hazard that is present in the air and will also display information on its built-in monitor (Fig. 5 & 6). The possibility of using a roaming sensor system is ideal for focusing on localized work in scenarios where it is not necessary to know the entire air quality layout of a shop. However, to supplement this type of sensing in a space that is large and open other scaling methods could be used. A considerable upgrade would be to supplement the roaming sensor system with a spread out network of air quality reading devices fixed in place.

A great example of this type of special engineering took place for the first time across the campus of MIT in 2014. The project known as Clairity is "a network…to measure local air quality and make it easily understandable to the public. [Clairity] deployed 24 sensor nodes on the MIT campus that monitor concentrations of five types of pollutants in both indoor and outdoor locations. Data collected from the sensors is available on a website in real time, and may be graphically displayed or downloaded by individual users." The live feedback and public nature of the project are proof that the implementation of air quality measuring at scale in the outdoors is on the horizon. It would only be natural that this high-resolution technology will appear soon in public indoor spaces as well [7].

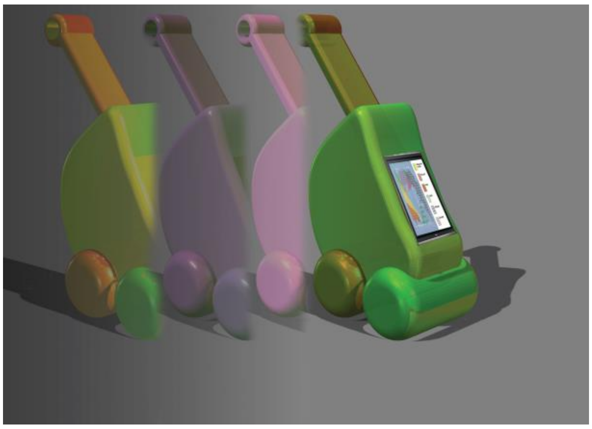

Fig. 5. Color shifting capabilities of Sensing-bot to signify types and levels of hazards.

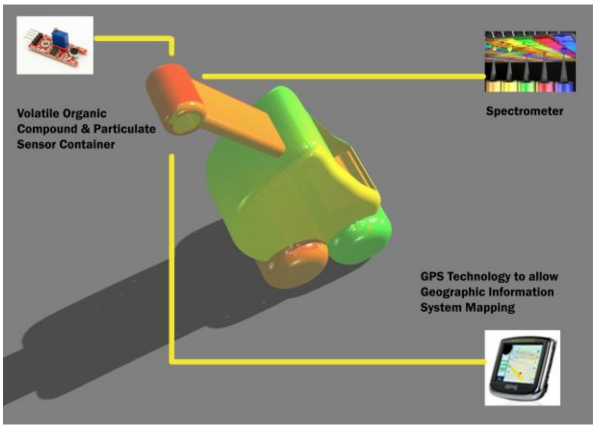

Fig. 6. Prototype of Sensing-bot for the Makerspace using chemical sensors and GPS technology for Geographic Information System (GIS) mapping and visualization.

Interventions in the form of monitors will also enhance the persuasive capabilities of the project. Three monitors, placed immediately outside the entrance of the shop (Fig. 3), on the main floor space of the shop and on the sensing-bot itself, will operate along the lines of Dr. Agnis Stibe Socially Influencing Systems [5], each showing the same information system:

- On the three screens information will be provided about the community of users of the shop.
- Interaction will be possible via milestones of safety conscious fabrication completed by users in the shop.
- An interface will display elements of recognition and competition amongst the users of the shop.
- A daily buddy or student safety monitor will be announced

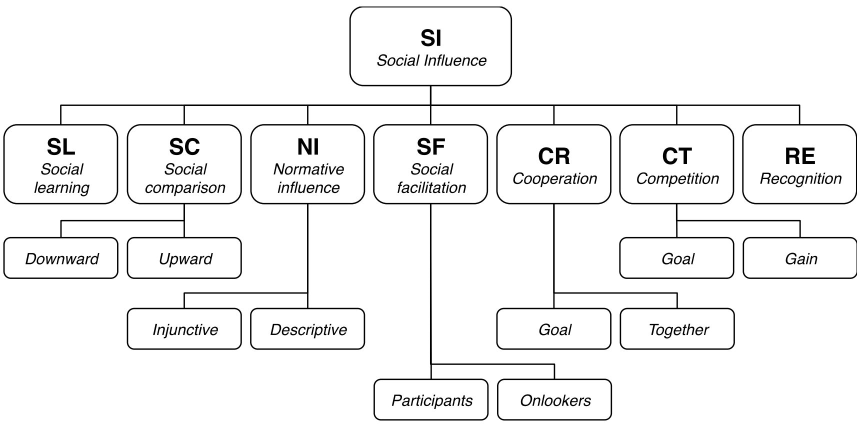

Fig. 7. Structure of the social influence aspects and their sub-dimensions [5]

The intervention in the Makerspace will base its interface on a set of dynamics of socially influencing systems (Fig. 7):

For phase A, screens will enumerate the amount of classes in the academic institution that use the shop. This information will show all shop users who else is working in the space over the course of the semester increasing the consciousness that the shop is a social environment and many people share the facilities. This can also create a common ground bolstering social presence.

Phase B will showcase a successful fabrication and prototyping effort conducted using the appropriate safety protocols and behaviors. This element is will embed recognition as a socially influencing system and increase self-esteem [6]. To accomplish this, a "safe user of the month" will be recognized along with a photo of them working on their project using safety gear.

Phase C will showcase the collective adherence to safety habits of working that certain class groups accomplished through out a given month. The goal here is to introduce competition as a socially influencing system by recognizing the safest class group on a leaderboard. Each month all groups can compete for placement like in the FIFA World Cup: after the 1st and 2nd place is selected, then the 3rd and 4th place will be selected by matching the two semifinalist class groups, afterward, 5th and 6th place will also be matched against each other. This method will aim promote competition overtime despite there being a clear first place.

Phase D will finally make use of the buddy system as provided by Dr. Samir Chatterjee [1]. Each day, a different student will be commissioned with watching over his classmates to make sure adherence to safe habits is carried out over the period of the day. The goal of this system is to add a layer of persuasion in the capacity of social facilitation [3]. It is key to remember that in the Makerspace, students are usually working without the supervision of experienced shop masters but social facilitation is possible, nonetheless.

References

1. Chatterjee, S.: Designing Mobile Persuasive Technologies to Assist and Monitor Heart-Failure Patients. Lecture, part of Advancing Wellbeing Seminar Series held at Media Lap, MIT, (Nov 17 2015)
2. Csikszentmihalyi, M. Flow: The Psychology of Optimal Experience. Harper Perennial (1991, first published 1990)
3. Guerin, B., Innes, J.: Social Facilitation. Cambridge, England: Cambridge University Press (2009)
4. Leigh, P.: Economic Burden of Occupational Injury and Illness in the United States (2013)
5. Stibe, A.: Socially Influencing Systems: Persuading People to Engage with Publicly Displayed Twitter-based Systems. Acta Universitatis Ouluensis (2014)
6. Wilson, S.R., Benner, L.A.: The Effects of Self-Esteem and Situation upon Comparison Choices During Ability Evaluation. Sociometry (1971)
7. Department of Civil & Environmental Engineering, Massachusetts Institute of Technology: Clairity. Http://clairity.mit.edu/site/html/home.html (accessed 15 November 2015)