Introducing the Maker Movement to Information Systems students

Machdel Matthee[1], Marita Turpin[1] and Dennis Kriel[2]

[1] Department of Informatics, University of Pretoria, South Africa
[2] Department for Education Innovation, University of Pretoria, South Africa
{machdel.matthee; marita.turpin; dennis.kriel}@up.ac.za

Abstract. This research reflects on the outcomes of a design thinking assignment given to first year Information Systems students. The assignment entailed the design and making of a corporate gift (or prototype thereof) by making use of the MakerSpace of the University of Pretoria. The assumption was that, by using the technologies provided by the MakerSpace, Information Systems first year students will get a tangible experience of applying design thinking. More importantly though, given the democratizing nature and economic potential of the Maker Movement, we hoped that by using the MakerSpace, students will get an understanding of the Maker Movement philosophy. From the students' feedback, it appears that students characterized the MakerSpace as enjoyable, inspiring, creative and enabling. A number of students noticed the potential for building their own designs and the ease in which rapid prototyping can be done using 3D printing. By using three components comprising the Maker Movement (making, maker spaces and maker as identity) we show that the experience led to a good understanding amongst quite a number of students about what the Maker Movement entails.

Keywords: Maker Movement, Maker Space, Information Systems, Information Systems curriculum, Information Systems students, rapid prototyping, design thinking

1 Introduction

"I want us all to think about new and creative ways to engage young people in science and engineering, whether it's science festivals, robotics competitions, fairs that encourage young people to create and build and invent – to be makers of things, not just consumers of things."

- President Barack Obama at the Annual Meeting of the National Academies of Sciences (April 27, 2009)

The Maker Movement is gaining traction in South Africa, as in the rest of the world. The Maker Movement is characterized by the "growing number of people who are engaged in the creative production of artifacts in their daily lives and who find physical and digital forums to share their processes and products with others."[1:496]. Hatch [2]

refers to the democratizing nature of this movement: design and manufacturing are now within the reach of everyday people through powerful computational and fabrication tools. The entrepreneurial and job creation potential of this paradigm is uncontested [3]. At the University of Pretoria (UP), a creative environment, the MakerSpace, was established two years ago. Technologies such as 3D printers, modelling software and Arduino boards are available for students to experiment and tinker with. The facility is staffed by student volunteers and is available to students from all faculties.

The Department of Informatics at UP decided to integrate the use of the MakerSpace in the curriculum of a new prescribed first year module on critical thinking and problem solving. Similar to engineering, problem solving in the information systems field requires not only analytical skills but also the ability to design and create new systems. Traditionally, the teaching of information systems development (ISD) has focused heavily on a linear development process, namely the Systems Development Lifecycle Process (SDLC) [4]. This method still forms the core of ISD teaching at the Informatics Department. However, in practice information systems developers often have to improvise to get working systems implemented under severe time constraints [5], so that a rapid prototyping design process is more appropriate. The Maker Movement's philosophy of creating, tinkering and hacking [6] aligns well with a process of improvisation and rapid prototyping. Furthermore, the Maker Space enables undergraduate students to experience the tangible results of their designs early on in their degree programme, long before they have acquired the ISD skills to have a similar experience from designing and developing software solutions.

In addition, although the MakerSpace can be used by all students, most of them are unaware of the facility and if they are, what the possibilities are of using the technologies. Our assumption was that, by letting students use the MakerSpace in doing their assignment, they will reach some understanding of the potential of the creative environment and the gist of the Maker Movement. The focus of this paper is therefore to reflect on 1) students' opinion on how the MakerSpace influenced their thinking in doing the assignment and 2) the ways in which the exposure to this environment opened their minds to new possibilities.

The next section provides an overview of the first year module and the MakerSpace assignment. This is followed by an analysis of students' opinions regarding the use of the MakerSpace. We conclude with a reflection on the findings.

2 The Problem Solving Module at UP

In this module, students were exposed to problem solving techniques. In addition to analytical techniques, design thinking was introduced as a way of solving problems. We realised that students require more than just analytical skills and the ability to solve textbook type problems, since in real life they are faced with complex and ill-defined problems. Design thinking is suited for dealing with ill-structured, open-ended problems, as opposed to analytical methods that lend themselves better to well-structured problems [7]. Design thinking is further characterised by a problem-solving

approach of building or putting together something, in contrast with analytical methods that attempt to solve problems by breaking them down into component parts [8]. This "building" approach of design thinking goes hand in hand with constructionist learning which is student-centred, participative and encourages the making of tangible objects [9].

3 The MakerSpace assignment

As part of their design thinking module, students received a problem-solving group assignment. They received an open-ended instruction, namely to design and develop a prototype of a corporate gift. In the process, they had to make use of the UP Makerspace in some way. Students were introduced to the Maker Movement during a lecture as well as a guided tour to the UP MakerSpace. At the Makerspace, they were introduced to the facilities and courses offered. Courses on offer included Arduino programming and 3D modelling. The facilities included a colourful "idea space", where students could have their planning meetings and get help from Makerspace assistants. The Makerspace also contained 3D printers and had a range of maker products on display.

Students had to do their assignments by means of a design thinking process. We suggested the Stanford design thinking process, as promoted by Stanford University's Hasso Plattner Institute of Design [10].

This design process consists of five phases: Empathize, Define, Ideate, Prototype and Test. The Empathize phase consists of getting to understand the user – their actions, motivation for the actions, their habits, emotions and world view. This is followed by the Define phase where, through sense making of the user's world, a meaningful problem statement is defined. Once this is done, the designer(s) can give free reign to their imagination and generate as many ideas as possible to solve the problem in the Ideate phase. During the Prototype phase, low resolution prototypes are built and tested at first and later followed by a more refined prototype. Finally, during the Test phase, the user interacts with the prototype(s) to evaluate it after which the prototype is refined. The Test phase provides another opportunity to understand the user through him/her interacting with the prototype meant to solve a specific problem. Although the phases are presented in a linear fashion, the phases are often revisited at any point in the design.

Students were given the opportunity to learn the design thinking process by means of a class exercise. The exercise was an adaptation of the Stanford design thinking crash course [11]. Students had to apply the five step process in pairs. In each pair, Person 1 had to identify a problem related to Person 2's student accommodation situation and design a solution for it, while at the same time, Person 2 designed a solution for Person 1's accommodation situation. Prototypes were made with recycled material in class. Great fun was had as the students designed solutions to better organize their class mates' study areas, designed multi-purpose furniture and addressed issues of privacy and noise, to name a few. The design thinking crash course was experienced as an effective means to get hands-on experience with the design thinking process, as preparation for the student group assignment.

For the group assignment, students also had to identify a potential client for whom they designed the corporate gift, give their product a marketable name and keep within a budget of R200. The Department provided the funds for the production of the prototypes. They also had to document their design thinking processes, rough sketches and 3D models in a blog, which, together with a demonstration of the final prototypes, formed the final mark of the assignment.

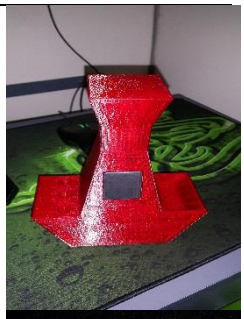
We were aware that most of the first year students did not have prior exposure to 3D modelling or the use of 3D printers. While training and facilitation was available at the MakerSpace, the students had to manage their own learning in this regard. They could choose what 3D modelling software to use, and were free to get design ideas from the internet. They were also allowed to get help from family and friends. Our aim was not to develop technological experts, but rather for students to gain exposure to the MakerSpace and maker philosophy in an unconstrained manner.

The prototypes they managed to design and develop were impressive and the class average for the group assignment was high. Section 3.1 below gives more detail about the artefacts that were created.

3.1 Corporate gift prototypes

A few examples of the 22 artefacts produced by the students are given below (Table 1). The description of each prototype was taken from the students' blogs.

Table 1. Prototypes of corporate gifts

Name	Description	Picture
Lamp paperweight	"The decision was made to construct a container which doubles as a paper weight that would contain a flashlight in an internal compartment and would have a variety of external utility features, the features being a multipurpose magnet embedded into the paperweight, a holder for paper clips, three holders for pens and a space to attach a "sticky note" pad."	
Pencil holder – building blocks	"A pencil holder that the users will build themselves."	

Zen Garden	"In the end the Zen garden was the chosen corporate gift as it has much more benefits and uses than any of the other suggestions. Such as, stress relief, a form of healthy escaped, a healthy outlet, etc."	
Mini Candy Machine	"A mini Candy Machine will bring colour into the office as candy is colourful. It will also be unique and make people happy. We would have to make it reusable so that the user will be able to put new candy in."	

4 Students' opinions on the use of the Maker Space

At the end of the module in June 2016, 81 of the 102 enrolled students completed an online questionnaire, asking students' opinion on several aspects of the module. The focus of this paper is on the answers to the two questions pertaining to the use of the Maker Space in the design and fabrication of the artefact:

Question 1: What influence did the MakerSpace environment have on your assignment?

Question 2: For which kind of problems/ projects/products would you consider using the MakerSpace again in the future?

The responses of the students on these two questions were qualitatively analysed and the findings are presented below.

4.1 Influence of the MakerSpace on the assignment

Students mentioned the role played by services provided by the MakerSpace in the successful completion of their assignment. Services such as 3D printing services, and advice and guidance provided by the staff were highlighted. The maker products in the MakerSpace, served as inspiration to some groups – it sparked ideas on what is doable. Quite a number of students referred to the influence the characteristics of the environment had on their motivation. From their responses the MakerSpace can be considered inspirational, creative, enabling, exciting, and enjoyable. In Table 2 below, we discuss these influences by giving a selection of quotes from the responses to support it, as well as the number of students who referred to it. 69 of the 81 students responded to this question.

Table 2 Influences identified from responses to Question 1

Influences	Quotes	Number of responses
	Services	
3D Printing and modelling	"It was a lot easier and faster to design and 3D print the prototype at the MakerSpace than to find the materials the time to build it ourselves" "The exposure we got to 3D printing as a technology certainly left a huge impression on me and all of my group members." "it helped only with the print of the toy and nothing else." "It helped us in the designing of our prototype" "New skill creating 3D sketches online and gaining knowledge on 3D printing"	20
Advice from staff	"They helped to generate ideas for the assignment" "It helped us in the designing of our prototype"	2
	Characteristics of the environment	
Exciting	"Created excitement amongst the group" "It helped us with our ideas and allowed us to be excited to do the assignment" "Gave life to everyone, quite being excited to print something as this was the first time one of us went to print something in 3D in your [sic] lives" "Very exciting and made us more motivated to do well in the assignment, having this opportunity." "MakerSpace was amazing, I loved it, would love to have more assignments such as this."	4
Inspiring	"It was inspiring to explore the existing items already made and use that as inspiration on our item" "It inspired us to think out of the box. "Thank you so much for exposing us to this wonderful place! It gave us knowledge of what the future could hold for us in technology."	3
Creative	"I felt more inclined to think out of the box there, as your surroundings are full of other peoples' creative inventions and designs." "I was completely exposed to a new innovative environment, in which is possibilities are almost endless. It	13

	sparked and interest for me in this innovative creative side of informatics." "The MakerSpace made me realise that whatever idea we come up with has to be original, simple, and yet creative."	
Enabling	"It enabled us to make our product." "They helped us to make a final product for much cheaper." "Made our whole assignment realizable" "It allowed us to use rapid prototyping the first time in our lives" "It made me see my work come to life" "The level of detail and commitment to the design of the prototype and pushing me to constantly iterate until I reach the optimal solution"	4
Challenging	"we took a picture there and realized that people out there are competitive and made sure that we up our game" "It taught us a great deal about compromise since we did not have prior knowledge of CAD or a higher budget,many of our ideals were made obsolete and it taught us that sometimes compromised have to be made in order to succeed."	2

4.2 Future uses of the MakerSpace

In response to Question 2, students pointed out the usefulness of the 3D printers and modeling software provided by the MakerSpace and their intention to use it in future. A number of students foresaw more assignments or projects requiring the use of the Maker Space during their studies at UP. Most students referred to the exiting possibility of designing something unique or customize existing artefacts and then have it printed. A large number of students considered prototyping as something they would consider using the Maker Space for in future. Table 3 below summarizes the future uses and a selection of quotes supporting the theme. 71 of the 81 respondents, answered this question.

Table 3 Future uses identified from responses to Question 2

Future uses	Quotes	Number of responses
Creating my own unique or customized items	"Projects and problems that involve creating something unique for a client." "designing a cup for someone and personalizing it by using his or her picture" "For my own personal projects to get some advice."	18

	"Maybe to print the odd thing or two that I design myself" "Making toys for my future children" "Printing an iPhone charger dock for my phone" "Building electronic gadgets and making robotronics" "Making required or needed parts for a product" "Making a penholder" "When I need an item that is unavailable in South Africa but available online 3D generating sketch site." "Making a gift"	
Arduino training	"For programming and Arduino courses"	2
Making anything creative	"For projects that require creativity" "Any creative problems that require us to think outside of the box and physically make something to fix it" "Anything with a need for creativity, whether it be making a physical object or not. The assistants help with ideas and practical advice" "Anything that can be made and is a physical item" Any project that a physical object needs to be created, because basically anything can be 3D printed.	6
(Rapid) prototyping	"Projects which require a prototype" "MakerSpace is very useful for printing out prototype designs for other projects." "I would use the MakerSpace to build a few of my own concepts that I have in mind and a few ideas that I would like to prototype. This is an excellent place to finally put an idea into an object. I will definitely be pursuing the MakerSpace to build a few of my own projects."	10
Future assignments at UP	"Future assignments in different courses at the TUKS." "any project that requires you to make a physical representation of the goal of the assignment." "also for assignments in business management where we need to create something as future entrepreneurs"	3

5 Discussion

The question now is, did the exposure to the MakerSpace give the students some understanding of the philosophy of the Maker Movement? Rosenfeld Halverson & Sheridan [1] identify three components of the Maker Movement: 1*) making* as a set of activities, 2) creative maker environments (*maker spaces*) as communities of practice and 3) *makers* as identities [1:496]. They argue that these three components are interdependent and its existence a necessary condition for any maker culture.

Making refers here to the activities towards the creation of a physical artefact. Hatch [2] considers the construction of physical objects as the one feature which distinguishes the Maker Movement from previous digital revolutions. Students had to follow a structured design approach for the making of the artefact. From students' blogs and responses, it is clear that they understand the MakerSpace as a place which enables one to create physical objects (e.g. "[The MakerSpace can be used for] anything that can be made and is a physical item").

Maker Spaces as communities of practice entail physical places destined for a "group of people to use as a core part of their practice" [1:502]. These spaces are characterized by co-participation and are not regulated. Participants can freely move in and out of the space. Making in these environments involves design thinking, computational thinking and innovation. The idea is to share tools and ideas in order to enable each other as problem solvers [12]. Some students sensed the open and creative character of the MakerSpace at UP. They considered the environment to be creative, inspiring, enabling and enjoyable. Although they did not become part of the community (as far as we know), they were exposed to an example of a maker space.

Maker as identity refers to the identity participants in the Maker Movement take on. They consider themselves *makers* who co-participate within the community to create artefacts. Rosenfeld Halverson & Sheridan [1] emphasize that not all participants will take on this identity. From the students responses it is clear that some students will embrace this new identity whereas others not. 18 students saw the opportunity to make their own artefacts in future whereas 3 students clearly said that they will not use the MakerSpace in the future.

From the discussion above, we deduce that for at least some students, the use of the MakerSpace in the assignment let them experience what the Maker Movement is about. The small number of responses for some of the themes shows that we cannot say this for the majority of students, but we believe it is a good beginning. It seems that some students feel more empowered now and might even consider becoming participants in future in the maker culture.

6 Conclusion

This paper argues that by introducing the MakerSpace to a design assignment of Information Systems, the students were not only given the tangible experience of applying design thinking, but were simultaneously exposed to the philosophy of the Maker Movement.

The MakerSpace at UP is only in its second year of existence and some teething problems were experienced in the beginning. Some students complained about the lack of resources and the consequent long printing job queues. We repeated this assignment in 2017 and to deal with bottle neck issues at the MakerSpace, introduced an earlier deliverable to prevent last minute printing jobs. This worked well and no complaints were received in 2017 regarding this issue.

Although we did not collect any demographic data, this is something that should be considered in future research. It would be interesting to understand what type of student takes on the identity of maker. Rosenfeld Halverson & Sheridan [1] refer to the male domination in the maker culture. Is this also true for our students? In addition, we believe that some aspects of the Maker Movement philosophy should be applied in the teaching of system design and engineering. For example, how can the learning environment in the computer lab be enhanced such that students experience an open and creative space where they can embrace the identity of information system makers? These and other related questions might be worth the while to investigate.

References

1. Rosenfeld Halverson, E., Sheridan, K.: The Maker Movement in Education. Harvard educational review, December 2014, 495 – 504 (2014).
2. Hatch, M.: The Maker Movement Manifesto. McGrawHill Education, NY (2014).
3. Seo-Zindy, R., Heeks, R.: Researching the emergence of 3D printing, Makerspaces, Hackerspaces and Fablabs in the Global South: a scoping review and research agenda on digital innovation and fabrication networks. The Electronic Journal of Information Systems in Developing Countries. 80(5), 1 – 24 (2017).
4. Whitten, I.L.D.,Bentley, J. L.: Systems Analysis & Design for the Global Enterprise. 7th edn, McGraw-Hill/Irwin, New York (2007).
5. Van der Merwe C., Turpin M., Hendriks S.: The development of a mobile information system to assess the food security of rural communities in South Africa. Proceedings of IST-Africa 2017 Conference, Windhoek, Namibia, 31 May - 2 June 2017 (2017).
6. Honey, M., Kanter, D.E. eds.: Design, make, play: Growing the next generation of STEM innovators. Routledge, New York (2013).
7. Jonassen, D.H.: Toward a Design Theory of Problem Solving. Educational Technology, Research and Development, 48(4), 63 – 85 (2000).
8. Cross, N.: Designerly Ways of Knowing. Design Studies 3(4), 221-27 (1982).
9. Alesandrini, K., Larson, L. Teachers Bridge to constructivism. The Clearing House, 119-121 (2002).
10. Hasso Plattner Institute of Design. An Introduction to Design Thinking Process Guide. (2010) Available at https://dschool-old.stanford.edu/sandbox/groups/designresources/wiki/36873/attachments/74b3d/ModeGuideBOOTCAMP2010L.pdf?sessionID=573efa71aea50503341224491c862e32f5edc0a9 [Downloaded 6 June 2017]
11. Hasso Plattner Institute of Design. A Virtual Crash Course in Design Thinking. (2017b) Available at https://dschool.stanford.edu/resources-collections/a-virtual-crash-course-in-design-thinking [Downloaded 8 June 2017]
12. Papavlasopoulou, S., Giannakos, M.N., Jaccheri, L. Empirical Studies on the Maker Movement, a Promising Approach to Learning: a Literature Review. Entertainment Computing. 18, 57 – 78 (2016).