

The Exploratory Study of Behavioral Intention to Use the 3D Printing Technology: A Case Study of XYZ Bakery and Coffee

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Abstract—The main objective of the study is to explore behavioral intention of using 3D printing technology at XYZ Bakery and Coffee. Based on the theoretical framework of the Technology Acceptance Model (TAM), the four aspects of TAM (intention to use; perceived usefulness; perceived ease of use; and job relevance) were examined. The paper presents a qualitative analysis of 8 participants' comments from semi-structured interviews in XYZ Bakery and Coffee during monthly meeting in October of 2016. The study demonstrated results on factors that have direct impact on the users' perceptions in relation to 'behavioral intentions of use' for 3D printing technology. Namely these are; 1) Perceived Ease of Use (PEU), 2) Perceived Usefulness (PU), 3) Job Relevance (JR). The findings also indicated 'Perceived Usefulness' as the determining component on the factor for 'intentions of use' in users who did not show intentions for use.

Index Terms—Technology Acceptance Model, 3D Printing Technology, Exploratory study

I. INTRODUCTION

Technology will become a key part in driving business across many sectors industry's productivity performance, as mentioned by Hermman et al. (2016). The 3D printing technology has been considered as trigger of the next industry revolution (Barnatt, 2013). It greatly plays apart in advancing technologies, where it contributes to scientific researches in aerospace industries, medical fields, and many studies in business industries. Although, this innovative technology is utilized in many industries such as like consumer products, accessories, automotive, business machineries, as it is just getting the attention from food industry there are much potential for its uses in this growing industry. Therefore, this is an opportunity to explore the potential intention to use 3D printing technology in Bakery industry. The focal study of the research is taken upon the XYZ Bakery and Coffee, which is one of business unit under umbrella of ABC Public Company Limited. It serves clients with bakery

and coffee in Thailand. XYZ Bakery and Coffee stands as a business Unit specializing in creating a Café style shopping experience with a mission of provides their best products on bakery and coffee. With over 300 branches, XYZ Bakery and Coffee was selected to be the study site as of its business should be matched with the study.

A. Literature Review Narrative

The most primitive 3D printing technology come to be noticeable firstly in the late of 1980's named Rapid Prototyping (RP) technologies at that time. Its origin was founded in 1986; the first patent was issued for Stereo Lithography Apparatus (SLA) to one Charles (Chuck) Hull, who first conceived it in 1983. Later on, Hull went to be the co-founder of 3D Systems Corporation, which one of the largest and most productive organizations in its operation today (The Free Beginner's Guide – History – 3D Printing Industry, 2016). As the reason of its procedures were initially considered a fast and more cost-effective technique for industry in generating prototypes for product development. Moreover, there have been many researches on the behavioral intention of using new technology. The technology acceptance model (TAM), proposed by Davis et al. (1989), has been broadly used to discuss external and internal motivational factors that drive ones behaviors.

B. The Technology Acceptance Model (TAM)

There have been numerous academic views which addresses the acceptance and uses of (IT) technology. The Technology Acceptance Model (TAM) proposed by Davis et al. (1989) is extensively recognized as it outlines the comprehension of IT users' authorization procedures. The model has shown to be idealistic as it clarifies the abundant of the divergence in users' interactive purpose associated to IT implementations and practices in wide circumstances. Furthermore, the model's superiority implications in numerous amounts of settings where there has been a sizable theoretical and empirical indication evident that it has accumulated the approval of the model's distinctions

as to other supernumerary models like Theory of Reasoned Action (TRA) and Theory of Planned Behavior (TPB) (Mathieson, 1991).

C. Conceptual Model

Mathieson (1991) mentioned that this is the model that is primary chosen to be dominant in the field. TAM is an intention-based model that stipulates the meaning of advocate knowledge as good predictor of definite practice. The model was shaped to clarify and forestall the upcoming of users' performance based on humble activities engaged in pre-adoption concise of the system or prototype. As suggested by Davis et al. (1989), there are two major perceptual factors that influence the users' intention for technology usage; 1) Perceived Ease of Use, and 2) Perceived Usefulness.

1. Perceived Ease of Use (PEU) is defined as "an individual's perception that using a system with less effort". It views systems as identical and the more time users spend on using, it can help to enhance job performance (Holden & Karsh, 2010).

2. Perceived Usefulness (PU) is defined as "an individual's perception that using a system will enhance job performance". It is the cognitive perception of people's judgments on the usefulness of a system by comparing its' capabilities on the needs to get the job done (Davis et al., 1989).

Job Relevance (JR) is defined as "an individual's perception regarding the degree that the target system is applicable the job" (Liang et al., 2003). Moreover, this is the external factor that has impact on users' Behavioral intentions (BI). According to Holden and Karsh (2010), the behavioral intention to use (BI) defines as "the motivation or willingness to exert effort to perform the target behavior".

D. Theoretical Construct

The basis of the determinants came from three major theoretical framework areas of studies.

Firstly, "Work Motivation Theory" by Vroom (1964) is discussed in supporting of the work motivation theory. Locke and Latham (1990) discussed achievements of goals through task-specific plans, in which performances are designated, united, and sequenced. Secondly, the "Action Theory", in social psychology by Fishbein and Ajzen (1975) is reviewed. Vallacher and Wegner (1987) endorsed a prepared perceptive representation of accomplishment, called the distinctiveness assembly. The distinctiveness construction seems as a straightforward inspiration by which people cognitively correct their performances in the persistence of higher-level goals (Vallacher & Kaufman, 1996). Thirdly, "Task-Contingent Decision Making" from the behavioral decision theory by Beach & Mitchell in 1978 is also reviewed. These are impacts of task-specific goals which guide the behaviors in the course of a conception-matching

process connecting contributory performances to goals (Bandura, 1986).

E. Related Research

For over a decade, there was wide-ranging practical evidence accumulated that professed ease of use as significantly linked to intention, both directly and indirectly via its impact on professed usefulness (Davis et al., 1989). Venkatesh and Davis (1996) model also professed ease of use as being dependent on one's general computer self-efficacy and adjusted to account for a system's objective usability via direct behavioral experience using the target system. However, other studies done on perceived usefulness gave other suggestions. Black et al. (1987) and Norman, (1987) did a study in human-computer interaction. Their result suggested similar goal-hierarchy models, but operating at a more micro levels of analysis like higher level goals (e.g., writing a document) and lower-level activities (e.g., level of keystrokes and mouse clicks). Kieras and Polson (1985) said that operators possess discrete acquaintance about their job condition, which they can use as a foundation for influential what jobs can be accomplished with a given system. Overall, there are many different variations of TAM model. The TAM extension often leave one those variable out of the model. As evident in the study by Tung et al. (2008) only studies the effects of independent variable on the intention to use the system. Therefore, in this study, we focus on the effects of three independent variables (Perceived Usefulness, Job Relevance, and Perceived Ease of Use) on the intention to use 3D printing technology.

F. Methodology Objective

The objective of this study is to explore behavioral intention to use 3D printing technology at XYZ Bakery and Coffee Framework of Study.

Based on the theoretical framework of the Technology Acceptance Model (TAM), the effects of three independent variables (Perceived Usefulness, Job Relevance, and Perceived Ease of Use) on the intention to use 3D printing technology were studied as illustrated in Figure 1.

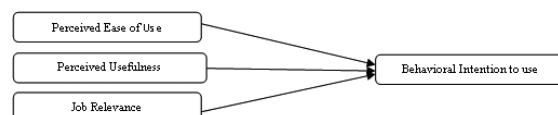


Fig. 1. Proposed framework adopted from Davis et al. (1989)

G. Research Design

Qualitative approach was adopted. Semi-structured conducted with eight volunteer participants (n=8); consists of five female and three male, from XYZ Bakery and Coffee in October of 2016 during monthly meeting. The details information of 3D printing technology was presented to all participants. The

interviews were conducted by second research with the assistance of a research assistance who recorded the interviews after the presentation. Participants were asked with the questions related to the factors of TAM framework as shown in Figure 1. The record from the interview was transcribed and sent back to interviewees for confirmation.

H. Findings & Discussions Perceived Ease of Use (PEU)

The 3D printer was designed to replace the manual process in creating new molds for baked bakery. Instead of creating mold for certain shape, 3D printer can shorten the process and makes it effortless. User can be created various shape of products based on their imagination. All participants believed that 3D printer is easy to use.

Positive Perception on Perceived Ease of Use

“My background was not related to IT. At first, I thought it required some IT background to work on this technology but the 3D printer is quite easily to operate.” - (Participant B).

“It is very simple to use. It doesn’t require intensive training to use it. I think it is great.” - (Participant F)

I. Perceived Usefulness (PU)

The purpose of the 3D printing technology aims at bringing valuable benefits to consumers. In businesses it aims to create value added products for customers. In summary, from the study all participants perceived that use 3D printing technology would be beneficial to their business.

Positive Perception on Perceived Usefulness

“This technology can provide an effective way to customize baked bakery for consumers. There were many times that we disappointed our customer who requested for sugar free or gluten free items. With this printer, we can keep up with our customer’s need.” - (Participant C)

■ “I think it is a good tool for me to be wild on the design and textures. It will change the experience of eating bakery period.” - (Participant E)

■ “If I’m able to provide personalized nutrition for my customers, it is a “must have” machine in my shop.” - (Participant G)

Mixed Perception on Perceived Usefulness

■ “For me, I think it is a great technology. But my only concern is the processing time for high volume orders during seasonal celebrations. We might not be able to keep up with incoming orders.” - (Participant H)

■ “Yes, it provides lots of useful feathers. I’m just wondering how easy to clean all the parts i.e. cartridges and printer heads. We are in food business; sanitization is our priority.” - (Participant E)

■ “Well, it can do one layer of ingredient at a time. If my creation supposedly has eight layers, then I have to switch cartridge of those ingredients back and forth. It could be a hassle.” - (Participant F)

Negative Perceptions on Perceived Usefulness

■ “Well, I think it is good as it gets for household users. I don’t think this technology is appropriated for commercial use in term of production times. It’s just my idea.” - (Participant C)

■ “What if the printer jams? Can it be easily to get fixed? We cannot wait for days to get it up and run.” - (Participant G)

Job Relevance (JR)

Job relevance was investigated as an external factor, in the study all participants has perceived importance of 3D printing technology for enhancing their job or improving performances. The following denotes the comments of the findings in the research.

Positive Perception on Job Relevance

■ “I think it is a great innovation. I can notice lots of benefits from using this technology. It might be time for adopting new invention to enhance our bakery business.” - (Participant A)

“Is it important to use this technology? For me, it is absolutely yes! With new technology like this, it can cut down prep time and improve the efficiency.” - (Participant D)

■ “I can definitely offer much more for my customers. I can create variety of designs for our bakery. Moreover, I can custom nutrition for different groups of consumer. It is a big plus for us.” - (Participant F)

TABLE I
PARTCO AMTS’ RESPONSES
THE IMPACT OF PEU, PU AND JR ON
BEHAVIORAL INTERNATIONAL TO USE (BI)

Participant	JR	PEU	PU	BI
A	Y	Y	Y	Y
B	Y	Y	Y	Y
C	Y	Y	N	N
D	Y	Y	Y	Y
E	Y	Y	Y/N	Y/N
F	Y	Y	Y/N	Y
G	Y	Y	N	N
H	Y	Y	Y/N	N

Table I represents the impact of PEU, PU and JR on Behavioral Intention to Use the 3D printer. The finding demonstrated that job relevance (JR) and perceived ease of use (PEU) had direct relationship

with behavioral intention to use (BI); participants who had a positive JR and PEOU shown intention to use the 3D printer.

Furthermore, participant who had positive perceived usefulness (PU) demonstrated intention to use 3D printer, and vice versa. For the three participants who had mixed PU: one intended to use 3D printer; one did not intended to use 3D printer; and one had mixed feelings. It appeared that PU was the determining factor that led to BIU; as two participants, who had positive JR and PEU but had negative on PU, did not intend to use 3D printer; three participants who had positive JR, PEU, and PU intended to use 3D printer.

Positive Perception on Behavioral Intention to Use

■ “Yes, I intent to use 3D printer. I think it is one of the most interesting technologies in the market. I can do so much more with this tool.” - (Participant B)

■ “It provides an innovative way of making bakery. We can serve wild range of consumers. I definitely intend to use 3D printer.” - (Participant F)

Those participants who did not intend to use 3D printing technology mostly concerned about the speed and costs of commercial grade 3D printer.

Negative Perception on Behavioral Intention to Use

■ “I think it is a great innovation. I can notice lots of benefits from using this technology. But it is quite expensive and, you know, the technology changes rapidly. I might wait for newer technology that offers at lower cost.” - (Participant C)

■ “Even though, I can offer more varieties for my customers; but the speed of production and cost of investment in 3D printer are major my concerns.” - (Participant G) The finding supported the importance of job relevance, perceived ease of use, and perceived usefulness in TAM. In this particular case, perceived usefulness played an importance role for behavioral intention to use 3D printing technology which supported by Adam (1992) and Ng et al. (2013). The reasoning behind the relative strong correlation of perceived usefulness and behavioral intention could be caused by performance of the technology. In the case of 3D printing technology, speed of production was the major concern for adopting this technology. However, the original TAM and the research studies yielded results that supported the idea that of primary factors influencing behavioral intentions.

J. Conclusion

The purpose of this study was to indentify the factors which influence users' behavioral intentions for the willingness to adopt 3D printing technology. With the development in new technology to simplify the process and reduce costs, the subject of user acceptance arises. This study has provided some insights into the intention to accept 3D printing technology by manager of XYZ Bakery and Coffee. Since the implementation

of this technology can be costly and face some users' unwillingness to accept this technology. Thus, it is important to study the behavioral intention to use of the intended users. TAM was adapted as the research framework. The qualitative interviews from eight participants indicated that job relevance (JR), perceived usefulness (PU), and perceived ease of use (PEU) had a direction relationship with the intention to accept and use 3D printer, our findings were similar with other scholars (Venkatesh & Davis, 2000; Liang et al., 2003; Moores, 2012; Holden and Karsh, 2010; Chang & Chen, 2016). Four participants respond that they intend to use; one participant appeared to be indecisive; four participants did not intend to use. To conclude, the management of XYZ Bakery and Coffee should carefully consider how best to adopt the 3D printing technology for their business based on the feedback of their staffs.

Implication

The implication of this study is to understand the determinants of behavioral intention to accept 3D printing technology in Bakery industry. 3D printing technology has many advantages; such as creating more complicated design for food's appearances, innovative textures and flavors, as well as make customizations to tailor for personal needs. Hence, the major benefit of this technology is to enable healthy life style of eating. The business can promote specific foods for specific consumer targets, for example; sugar free items for people with diabetes; gluten free items for those who are allergic to wheat and low carb diets for people who wants to control/lose weight. As for the elderly, selections of soft texture foods with high nutritional value could be offered. As for children, they can offer a creative way for luring kids to eat vegetables by providing more an alluring appearance to attract their appetite. As the many benefits this technology offers, there are certain downsides, the speed of production is limited therefore it might not be able to suit the needs for mass productions to the demands. In the rapid world of technology, today's ever-changing developments are rapid; therefore, businesses must be able to keep up in order to gain competitive advantages.

K. Limitations and Future Research

The results and their implications come from one Bakery Company; hence, results may not be generalizable to other Bakery companies. Future research could address the limitation by conducting similar studies at a number of other Bakery companies to assess the degree to which the current findings are represented in other environments.

The qualitative study was conducted with only eight participants, so it is inappropriate to generalize the finding. Future research could combine both qualitative and quantitative research methods.

L. Acknowledgements

Researchers would like to thank the Dean, XYZ Bakery and Coffee, and all cited experts that contribute to this study. Our sincere thankfulness is extended to all anonymous respondents that devoted their valuable time for answering the questionnaires as well.

REFERENCES

[1] A. D., Adams, R. R., Nelson, and A. P. Perceived. (1992, Jan.). usefulness ease of use and usage of information technology: a replication. *MIS Quarterly*. 16(2), pp.227-247. Available: <http://www.jstor.org/stable/249577>.

[2] I. Ajzen. (1991, Dec).The theory of planned behavior. *Organizational Behavior and Human Decision Processes*. 50(2), pp. 179-211. Available: <http://www.researchgate.net>.

[3] C. Barnatt. (2013, May) .3D Printing: The Next Industrial Revolution. Create Space Independent Publishing Platform. Available: <http://www.amazon.com>.

[4] A. Bandura. (1986, Dec).Social Foundations of Thought and Action: A Social Cognitive Theory. Englewood Cliffs, NJ: Prentice-Hall..pp. 617.Available: <http://www.amazon.com>.

[5] L. R. Beach, and T. R. Mitchell. A contingency model for the selection of decision strategies. *Academy of Management Review*. 3, pp. 439-449. 1986.

[6] B. J. Black, S. D. Kay, and M. E. Soloway. Goal and plan knowledge representations: From stories to text editors and programs. In Carroll, J.M. ed.). *Interfacing. Thought*. pp. 36-60. The MIT Press, Cambridge, MA. 1987.

[7] F. Davis. (1989,Sep). Perceived usefulness, perceived ease of use and user acceptance of information technology. *MIS Quarterly*. 13(3), pp.319-340. Available https://www.jstor.org/stable249008?seg=1#pageScan_tab_contents.

[8] M. A. Fishbein, and I. Ajzen. (1975, May). Belief, Attitude, Intention and Behavior: An Introduction to Theory and Research. Addison-Wesley, MA. Available: https://www.researchgate.net/publication/233897090_Belief_attitude_intention_and_behaviour_An_introduction_to_theory_and_research.

[9] M. Hermann, T. Pentek, and B. Otto., “Design Princiles for Industries 4.0 Scenarios. 49th Hawaii International Conference on System Sciences HICS. 2016.

[10] R. J. Holden. and B. Karsh. The technology acceptance model: its past and its future in healthcare. *Journal of Biomedical Informatics*. 43, pp.159-189. 2010.

[11] E. D. Kieras and G. P. Polson. (1985). An approach to the formal analysis of user complexity. *Internation Journal of Man-Machine Studies*. 22, pp. 365-394. Available: https://www.researchgate.net/publication/220107999_An_Approach_to_the_formal_analysis_of_user_complexity.

[12] H. Liang, Y. Xue, and A. T. Byrd. PDA usage in healthcare professionals: testing an extended technology acceptance model. *Int. J. Mobile Communications*. 1(4), pp. 372-389. 2003.

[13] A. E. Locke, and P. G. Latham. A Theory of Goal Setting and Task Performance. Englewood Cliffs. NJ: Prentice-Hall. 1990.

[14] K. Mathieson. Predicting user intentions: Comparing the technology acceptance model with the theory of planned behavior. *Information Systems Research*. 2(3), pp. 173-191. 1991.

[15] T. McCue. Wohler Report. Retrieved from Forbes Available: <https://www.forbes.com/sites/tjmccue/2016/04/25/wohlers-report-2016-3d-printer-industry-surpassed-5-1-billion/#55dcfa0a19a0>. Apr. 2016.

[16] T. T. Moor. Towards Towards an integrated model of IT acceptance in healthcare. *Decision Support Systems*. 53, pp. 507-516. 2012.

[17] A. D. Norman. Cognitvie Cognitive engineering-Cognitive science. In J.M. Carroll, (Ed.) *Interfacing Thought: Cognitive aspects of human-computer interaction*. pp. 325-336. Cambridge, MA: MIT Press. 1987.

[18] H. Oh. and H. C. (2016, Sep.) Volitional degrees of gambling behaviors. *Annals of Tourism research*. pp.618-637. 2001. The Free Beginner’s Guide - History - 3D Printing Industry. Retrieved from 3D Printing. Available: Industry:<https://3dprintingindustry.com/3d-printing-basics-free-beginners-guide/history/>.

[19] Vallacher, R. R. and Wegner, D. M. What do people think they’re doing? Action identification and human behavior. *Psychological Review*. 94, pp. 3-15. 1987.

[20] R. R. Vallacher and J. Kaufman. Dynamics of action identification: Volatility and structure in the mental representation of behavior. In P. M. Gollwitzer, & J. A. Bargh (Eds.). *The Psychology of Action: Linking Motivation and Cognition to Behavior*. pp. 260-282. New York: Guilford Press.

[21] V. Venkatesh and D. F. Davis. A Model of the Perceived Ease of Use Development and Test, *Decision Sciences*. 27(3), pp. 451-481. 1996.

[22] V. Venkatesh. and D. F. Davis (2 A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management Science*. 46(2), 186-204. 2000.

[23] E. W. M. Ng, R. H. Shroff, and C. P. Lim,. Applying a Modified Technology Acceptance Model to Qualitatively Analyse the Factors Affecting E-Portfolio Implementation for Student Teachers’ in Field Experince Placements. *Issues in Informing Science and Information Technology*. 10, 355-365. Vroom, V. H. (1964). *Work and Motivation*. New York: Wiley. 2013.



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