EXPLORING AND PROPOSING A BUSINESS MODEL FRAMEWORK FOR THE ONLINE MARKET PENETRATION OF 3D PRINTERS

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ABSTRACT

The recognition of Thailand's 3D printing industry as a growing sector has prompted the current study's objective to explore prospective approaches to capitalize digital tools and online platforms in commercializing 3D printers. Having conducted secondary research as well as preliminary interviews with industry experts, data was collected using an online survey in order to assess the factors influencing online purchase of 3D printers. Consequently, the sample consisted of 3D printer users in business (66.7%), leisure (17.3%) and educational (16%) contexts. To analyze the data, multiple statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS). Findings were discussed in juxtaposition with examined literature. The most important factors were identified to be related to sellers' technical facility and specialist service.

KEY WORDS: 3D Printer / 3D Printer Online Purchasing / Virtual Reality / Post Service of 3D Printer / Virtual Showroom Tour

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CHAPTER I
INTRODUCTION

Advancements in technology have unarguably transformed the operations – if not altogether prompted paradigm shifts – of many industries. Among recent innovations is the transformative technology of 3D printing – an additive process that enables the physical construction of digital designs or models; developed to optimize manufacturing efficiency (Shahrubudin, Lee, and Ramlan, 2019). With reference to Campbell, Williams, Ivanova, and Garrett (2011), 3D printing technology or additive manufacturing denotes groundbreaking implications for design and manufacturing along with the economic, environmental, and geopolitical contexts they inhabit. Au contraire to conventional manufacturing processes that entail the assembly of numerous parts from an array of sources, 3D printing scales the production series down to a single centralized procedure – allowing reductions in required components, labor, and energy; not to mention the abolishment of geographical restrictions imposed by the imbalances in different countries' manufacturing capability (Campbell et al., 2011).

Owing to such exemptions, the translation of intangible models to physical materials has been made accessible for the general public as well as practitioners of various disciplines via relatively inexpensive devices and enabling softwares (Khosravani and Reinicke, 2020; Petrick and Simpson, 2013; Oropallo and Piegl, 2016). According to Rayna and Striukova (2016), 3D printing is growing in its popularity not only as a tool within product design or traditional manufacturing settings, but also for use within the home environment. Commensurably, the global 3D printing market reached a value of 15.10 billion US dollars in 2021 and is anticipated to surpass 18.30 billion US dollars in 2022 (Globe Newswire, 2022). In addition to being driven by the fourth industrial revolution and insurgency in digitization trends, the maturation of the 3D printing industry can be attributed to the disruptions resulting from the recent COVID-19 pandemic. As illustrated

in a report by Bain & Company, a renowned global management consulting firm, the unprecedented virus outbreak had incited cessations of manufacturing processes worldwide – necessitating investments in supply chain resilience in order for firms to persevere with minimized risks (Schatteman, Woodhouse, and Terino, 2020). As scholars Paul, Moktadir, and Ahsan (2021) have suggested, "technologies such as 3D printing can simplify supply chains, transform global supply chains into highly flexible and responsive local supply chains which is essential during and after any disruptive situations such as COVID-19." (p. 13).

The shifting role of 3D printing technology itself is not the only byproduct of the accelerated digitalization trends engendered by COVID-19. In congruence with observations in most other sectors, 3D printing providers and consumers have increasingly been observed to utilize online platforms – specifically with regard to 3D printing services (Zeal 3D, 2022). Although the online distribution of 3D printers is not an area that has been delved into with respect to pandemic-induced implications, it can be surmised that surging online consumption trends have favorably impacted the market of 3D printers. Online shopping platforms such as Amazon and Alibaba – where 3D printers are also sold as a major category – have experienced rises in sales revenue and deliveries (UNCTAD, 2022; 3D Natives, 2022). Therefore, an investigation into the dynamic of this phenomenon – with a specific attention to 3D printers as a product category marketed online – is anticipated to shed light on the present e-commerce context for a budding innovation.

However, 3D printing differs from other technologies introduced to the manufacturing value chain in its community of developers; such that it did not originate from established companies focused on customarily large business-to-business undertakings, but rather an ecosystem of "makers" avid in using the innovation for small-scale productions (Piller, Weller, & Kleer, 2015). Accordingly, entrepreneurs in the 3D printing industry may adhere to business models dissimilar to that of firms supplying other manufacturing technologies, given 3D printing ventures' relatively small operations and recent development (Holzmann, Breitenecker, Soomro, and Schwarz, 2017). In spite of 3D printing's escalating prevalence and importance in the contemporary context, empirically-based knowledge of the technology from a business perspective is considered to be in its

infancy – a majority of investigations delving into 3D printing applications rather than the business components and directions of 3D printing enterprises themselves (Holzmann, Breitenecker, and Schwarz, 2019). Coupling this with the lack of insights pertaining to consumers' view of 3D printers as a commodity, the challenge for 3D printing businesses in understanding end users and determining a prospectively advantageous approach is all the more difficult (Perry, 2018).

Acknowledging these shortcomings in the research realm, the present study aims to examine the 3D printing industry with a particular focus on arriving at recommendations for 3D printing businesses' penetration in the online market. Guided by secondary research findings, the study will inquire into the topic by collecting and analyzing primary data from practitioners in the 3D printing market. Ultimately, a discussion of the current study's results in collation with the conclusions of previously conducted studies will be put forward and hopefully inform directions for approaching online consumers. Considering that 3D printing is a unique, ambiguous, and evolving area of business underexplored in academia, it is intended that the study will not only yield pragmatic implications for professionals in the field, but also invite future research to probe into the dynamic of the 3D printing industry.

CHAPTER II
LITERATURE REVIEW

Corresponding to the present study's objective of examining the 3D printing industry with respect to potential online penetration approaches for trading 3D printers, a literature review is performed to ultimately arrive at a well-founded research framework – which in turn guides primary data collection and analysis. The review thus first centers on grasping the current state of 3D printing technology, including its opportunities and challenges as an innovation. This then paves the way for apprehending the dynamics, complications, and segmentations of the 3D printing market. Subsequently, such insights inform directions for marketing approaches – particularly by permitting the understanding of consumer needs, based on which attracting factors can be identified. To complement the entire perspective, current online consumption trends are explored in order to shape potential initiatives for online distribution of 3D printers.

2.1 3D Printing Technology

As previously mentioned, 3D printing technology operates on the fundamentals of additive manufacturing wherein layers of materials are annexed to create three-dimensional formations (Kamran and Saxena, 2016; Shahrubudin, Lee, and Ramlan, 2019). The American Society of Testing and Materials (ASTM) (Calignano et al., 2017) has tabulated 3D printing into 7 distinct process categories that differ by the techniques and material applications: binder jetting, direct energy deposition, material extrusion, material jetting, powder bed fusion, sheet lamination, and vat photopolymerization. Corresponding materials for each process category are detailed below (see *Table 1):*

Table 2.1. 7 Types of 3D Printing

Process Category	Description	Materials
1. Binder jetting	Droplets of liquid binding agent are deposited on a bed of granulated materials, which are later sintered together	Metals, ceramics, sand, plastics
2. Direct energy deposition	Molten metal simultaneously deposited and fused	Almost any weldable metal
3. Material extrusion	Molten thermoplastic is deposited through a heated nozzle	Filaments
4. Material jetting	droplets of liquid photosensitive fusing agent are deposited on a powder bed and cured by light	Photopolymers, flexible plastics, casting wax, metals, ceramics
5. Powder bed fusion	powder particles are fused by a high-energy source	Polypropylene, plastics and nylon composites
6. Sheet lamination	individual sheets of material are cut to shape and laminated together	Ceramics, papers, metals, fiber-reinforced polymers, and most polymers
7. Vat photopolymerization	liquid photopolymer is cured by light	Photopolymer resins

(Hubs, n.d.)

As the above figure has illustrated, different processes of assembly and rapid prototyping each has its own unique chemical and mechanical qualities – enabling various materials to be maneuvered in additive manufacturing (Kamran and Saxena, 2016; Khosravani and Reinicke, 2020; Loughborough University, n.d.). On account of this, the techniques of 3D printing – regardless of the process categories – provide customized solutions for manufacturing practices with limited geometric constraints; therefore recognized as a critical driving force in the era of industry 4.0 (Dilberoglu, Gharehpapagh,

Yaman, and Dolen, 2017; Ziaee and Crane, 2019). As scholars have concurred, 3D printing not only allows the economic competitiveness of manufacturing operations, but also empowers "smart" production that capitalizes on new technologies and delivers materials that are of desired properties while ensuring the minimization of labor and time input (Dilberoglu, et al., 2017; Zawadzki and Żywicki, 2016). Coupling such recognition with the accelerated trends of automation, Internet of Things (IoT), digitalizations and such, it is of no surprise that industries at present are increasingly incorporating 3D printing for high-intricacy parts, in addition to mass production (Kamran and Saxena, 2016). Moreover, given the increasing accessibility and inexpensive options of desktop 3D printers, personal and household use of 3D printing technology has recently materialized – example applications include designing appliances, replacement parts, or creative hobbies (Hannibal & Knight, 2018). Nevertheless, the realm of 3D printing is far from being scrupulously investigated in terms of its implications for the environment, health and safety of workers, and the redefined role of labor – thus posing notable limitations as a continuously advancing innovation (Khosravani and Reinicke, 2020).

2.2 Overview of the 3D Printing Market

At its emergence, 3D printing technology was recognized primarily for its facilitative capability to the design practice. However, it has developed to be a tool for use in various industries and businesses, as previously noted (Kamran and Saxena, 2016). With reference to Holzmann, Breitenecker, and Schwarz (2019), this has largely been driven by trends for individualization – whereby a shift in power from companies to consumers has compelled the former to simultaneously ensure quality, cost-effectiveness, and personalized offerings in addition to keeping pace with new technologies. The competitiveness of the 3D printing industry, therefore, is discerned to be challenging owing to the entrepreneurial opportunity of 3D printing businesses' relatively low investment cost with a sizable prospective market (Holzmann, Breitenecker, Soomro, and Schwarz, 2017). At the present, the 3D printing domain can be segregated into two different contexts: industrial 3D printing

– reshaping production lines and value chains towards mass customization – and consumer 3D printing – for learning and craftsmanship (Van der Zee, Rehfeld, and Hamza, 2015).

2.2.1 Target Groups of 3D Printers

With reference to Matias and Rao (2015), the market of 3D printing comprises both consumers and businesses that are identified as "users" of 3D printers. To elaborate, consumers apply the use of 3D printers for exploring their creativity and improving or developing products that befit their specific needs – thus the group may be referred to as "makers" (Foege, 2013). The empirical work of Matias and Rao (2015) has revealed that makers that purchase 3D printers presently occupy a minor proportion – given that decisions for 3D printer ownership is contingent on willingness to spend on the technology, perceiving the apparatus as a creative solution rather than for serving business or commercial purposes. In other words, consumers that do purchase 3D printers recognize the technology's potential for facilitating their learning experience and experimentation thus are more likely to purchase 3D printers; contrary to those that view 3D printers as business tools with declining value over time. The authors have also unveiled that, with regards to the target group of businesses, there exist three main segments in the 3D printing industry; namely, consumer 3D printing companies, 3D software companies, and 3D printing services that aim to address unique 3D printing requirements. Further, it was found that businesses in the 3D printing industry are distinct to others such that, beyond striving to maximize revenues and minimize costs, their objective centers on educating those within as well as outside the organization regarding 3D printing technology (Matias and Rao, 2015).

2.2.2 Gaps and Needs in the 3D Printing Industry: Implications for Thailand

In spite of current practitioners' efforts to educate existing and potential users of 3D printing technology, a notable knowledge gap exists with respect to the market's software skills for 3D design and knowledge of the 3D printing workflow (Harmon, Klein, Im, and Romero, 2022; Matias and Rao, 2015). Referring to the suggestion of Steenhuis

and Pretorius (2016), it is imperative for the technology and its instrument to enhance technological capabilities and user friendliness to encourage user adoption. However, the conclusions of Matias and Rao (2015) indicate that the described disparity is not attributed to the availability of user-friendly software – as these are already being offered in the market – but the perception of consumers toward these packages as being easy to use and learn about. A more recently conducted study showed that at the present adoption rates and purchases of 3D printers have improved – illustrating a shift of concern toward consumers' ineffectiveness in utilizing the technology to its full potential, provided the mentioned dearth of knowledge, rather than the acceptance of the technology itself (Ben-Ner and Siemsen, 2017).

Regardless, markets wherein pervasive adoption of 3D printing is lacking – such as locations relatively lagging in technological literacy – still require attention with respect to 3D printing knowledge gap and user adoption. According to a global leader in manufacturing solutions provider, New Kinpo Group, the Southeast Asia market is especially challenging for the penetration of 3D printing businesses owing to the region's large gap of 3D printing knowledge. The Taiwan-based conglomerate also identified Thailand as the ASEAN hub for 3D printing business by virtue of the country's "strong culture and creative design" with a profusion of local designers and small-to-medium sized businesses, demonstrating great potential to grow in 3D printing adoption (The Nation Thailand, 2022). This could appreciably address the knowledge gap and promote 3D printing activities in the market, as the entry of more 3D printer businesses denotes facilitating conditions for the acceptance and utilization of 3D printing technology, among consumers' "do-it-yourself" mentality and hedonic motivation to use 3D printers (Halassi, Semeijn, and Kiratli, 2018).

2.2.3 The Future of 3D Printing in Industry 4.0

With the anticipated growth of 3D printing in a largely underdeveloped market of ASEAN and, more specifically, Thailand, it can also be foreseen the emergence of other innovations amidst the present industry 4.0's demands for more accelerated technological adoptions. As previously mentioned that 3D printing is recognized as one of the critical

impetus for the current industrial revolution (Ziaee and Crane, 2019), Internet of Things (IoT) and cloud technology are deemed to be equally important accompanying advancements in the design and manufacturing realm. According to the suggestion of Singh et al. (2021) the integration of innovation and information technology permits the digitalization of operations such that both efficiency and sustainability can be optimized. A case in point is the incorporation of 3D printing and cloud technology – a product of which is 3D printing cloud platform service. Consequently, users can access on-demand and customizable services while minimizing costs, maximizing the use of resources, and capitalizing on the flexibility yielded by the technology (Singh et al., 2021).

While extant literature on the future of 3D printers specifically is lacking for the Thailand market, implications can be derived from experts' view on the industry's approaching future. As current pioneering users of 3D printers are observed to utilize design databases for 3D printing – and some may presently own 3D printers for their at-home on-demand use, prospective trends are anticipated to encompass consumers' shifting purchasing behaviors; such as less dependence on mass producers and increased focus on addressing localized needs (Jiang, Kleer, and Piller, 2017). On an industrial level, it is predicted that 3D printers will become the method of dominance for serial production – making the technology become more mainstream, as opposed to its current position as a solution for prototyping. With a growing attention to learning and development on 3D printing, adoption and application of the technology is expected to expand. Accordingly, the future 3D printing market is foreseen to comprise both consumers and businesses with manufacturing operations as well as those with requirements for developing small customized items, such as the dental industry (AMFG, 2019). Regardless of the largely favorable lookout for 3D printers, scholars remain somewhat skeptical given the unpredictability of the business and market (Jiang, Kleer, and Piller, 2017).

2.3 Marketing Directions for 3D Printers

Referring to the formerly noted challenge in the market of 3D printing, scholars have suggested that addressing the knowledge gap and encouraging positive attitudes among consumers are anticipated to increase adoption and utilization rates (Harmon, Klein, Im, and Romero, 2022; Matias and Rao, 2015; The Nation Thailand, 2022). Accordingly, a classification of 3D printing adopters can be identified as follows, derived from the work of Mavri, Fronimaki, and Kadrefi (2021):

Table 2.2. Classification of 3D Printing Technology Adopters

Group of Adopters	**Characteristics**
Innovators	● Recognize the power of 3D printing ● Convinced of 3D printing's capability to transform their imagination into reality ● Perceive 3D printing as a provider of opportunity to design without limitation for creativity
Informed	● Seek to be informed of every new technology ● Willing to study about 3D printing to understand how it works along with its implications ● Will easily adopt 3D printing technology but are not technological pioneers
Ecologists	● Perceive 3D printing as "green" and "clean" ● Interested in pro-environmental solutions
Engineers	● Interested in the changes elicited by 3D printing technology – including the implications for production and manufacturing chains ● View 3D printers as an enabler of on-demand printing of products
Re-Users	● Hold a strong belief of recycling as a valuable solution for waste minimization ● View that plastic could be re-used and transformed into a filament for printing environment- and user-friendly objects

(Mavri, Fronimaki, and Kadrefi, 2021)

Based on the results of Mavri, Fronimaki, and Kadrefi (2021)'s study, therefore, businesses in the 3D printing industry – including manufacturers and distributors of 3D printers – could tailor their marketing approaches to the unique viewpoints and characteristics associated with each group of adopters. In particular, while investigated adopters' perception toward 3D printing is that the technology has transformative implications, individuals categorized as "innovators", "ecologists", and "re-users" demonstrated higher tendencies to adopt 3D printing than others. Moreover, all groups of adopters exhibit their intentions to use 3D printers for tinkering purposes – but only "innovators" and "engineers" are identified with potential to become inventors beyond exploring their creativity to repair or improve products (Mavri, Fronimaki, and Kadrefi, 2021).

2.4 Online Consumption Trends Post COVID-19

Prior to the outbreak of COVID-19, the online 3D printing market was already experiencing growth worldwide. Figures have indicated that demands from North America for 3D-printed components or products occupied the largest proportion at 49.4% – followed by demands from Europe at 41% (Varotsis, 2019). Corresponding to the recent observation from New Kinpo Group (The Nation Thailand, 2022), the Asia market was lagging behind in consumer demands for 3D printing but was also observed to be emerging (Varotsis, 2019). The recognition of 3D printing, however, has rapidly risen during the pandemic provided its applications in manufacturing to support protective measures against the virus as well as to serve non-medical purposes wherein normal production activities have been severely restricted (Amin, Nguyen, Roser, and Abramowicz, 2020; Salmi, Akmal, Pei, Wolff, Jaribion, and Khajavi, 2020). As stated by Choong et al. (2020), "3D printing has stepped up to become a vital technology to support improved healthcare and our general response to the emergency" during the COVID-19.

Given that it enables the development and modification of online designs, 3D printing removes the geographical and physical bounds for creativity and production; an advancement that can persist into business-as-usual beyond the outbreak. An example case is the retail sector – which Cui and Lee (2021) have found that the rapid e-commerce growth resultant of the pandemic has obligated consumer goods businesses to implement both online and in-store operations. With this acclimatization, 3D printing has also come into play such that it has been adopted to manufacture exclusive products for online distribution. Although the extant literature regarding online sales of 3D printers themselves – not other product or service areas associated with 3D printing – cannot be identified, the empirical works discussed along with the observed growth of online marketplaces where 3D printers are distributed (UNCTAD, 2022; 3D Natives, 2022) undoubtedly connote the product's prospect in an online environment.

CHAPTER III
RESEARCH METHODOLOGY

The section inaugurates with an outline of the research questions and objectives – ultimately formulating the present study's research framework. Accordingly, details of the chosen method, procedure, and ethical considerations are provided.

3.1 Research Questions

- What is the current state of the 3D printing realm in Thailand?
- What are the challenges and opportunities for 3D printers' online market penetration?
- What are the potential business directions for sellers of 3D printers?

3.2 Research Objectives

- To assess the current state of Thailand's 3D printing realm.
- To identify the challenges and opportunities for 3D printers' online market penetration.
- To develop potential business directions for sellers of 3D printers.

3.3 Research Framework

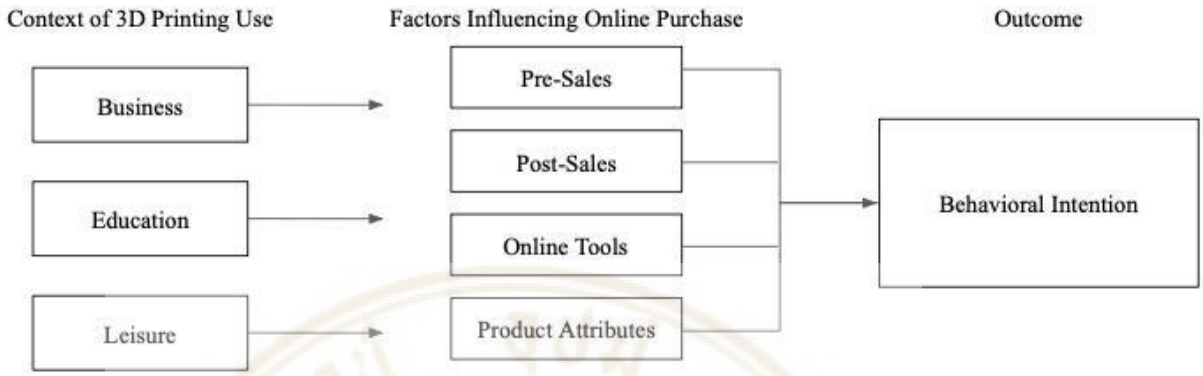

Figure 3.1. Research Framework

3.4 Method

The method selected for pursuing the research topic is quantitative – entailing the administration of online surveys for data collection followed by statistical analyses. In line with the recommendations of Goertzen (2017), quantitative research is evaluated as appropriate for the current study's objective to examine the "what" – concerning the understanding of Thailand's 3D printing landscape – and "how" – appertaining to the relationship between different factors and consumers' intention to purchase 3D printers online, and deducing the approach via which practitioners can penetrate the online market. With an emphasis on measurable and objective data, the current investigation's results can be collated with previous findings and generalized to the population of 3D printer users in Thailand.

3.4.1 Data Collection

In line with the quantitative approach selected, primary data is collected via surveys – comprising multiple-choice and Likert-scale questions to elicit participants' responses per the question items listed. Preliminary interviews with practitioners and users of 3D printers were conducted and the findings of which (see *Appendix A)* were used to

guide the survey design – centring on 3D printer users' potential to purchase 3D printers via online channels.

Table 3.1. Survey Items

Construct	Question Item	Response Options
Screening Questions	1) Have you ever heard about 3D printing technology?	- Yes - No
	2) Have you had experience using a 3D printer?	- Yes - No
	3) Have you ever had experience purchasing online 3D printers? 3.1.) (following a 'No' response) Are you interested in doing so in the near future?	- Yes - No
	4) Do you use/intend to use 3D printers for business, education, or leisure purposes?	- Business - Education - Leisure

Table 3.1. Survey Items (cont.)

Construct	Question Item	Response Options
Factors Influencing Online Purchase	*Pre-Sales* 1) To buy a 3D printer online, it is important for me to be provided an introduction or demo session by the seller first 2) To buy a 3D printer online, it is important for me to be invited to a knowledge sharing session/event first 3) To buy a 3D printer online, it is important for me to be provided some kind of bundle deal — such as a software subscription together with the purchase 4) To buy a 3D printer online, it is important for me to be provided a test print sample/benchmark first 5) To buy a 3D printer online, it is important for me to be provided a benchmark analysis of the work specification first i.e. accuracy, tolerance, strength 6) To buy a 3D printer online, it is important for me to be able to ask questions and receive sufficient answers first	Please indicate your level of agreement with the presented statement: 1 = strongly disagree 2 = disagree 3 = neutral 4 = agree 5 = strongly agree

Table 3.1. Survey Items (cont.)

Construct	Question Item	Response Options
Factors Influencing Online Purchase	*Post-Sales* 7) I would be more likely to buy a 3D printer online if the seller can provide on-site technical engineer support — such that the staff can visit my office/house to troubleshoot the printer 8) I would be more likely to buy a 3D printer online if the seller provides installation service 9) I would be more likely to buy a 3D printer online if the seller provides technical support at the store/service center — such that I can go to the store/service center for help 10) I would be more likely to buy a 3D printer online if the seller provides workshops for me to learn new techniques 11) I would be more likely to buy a 3D printer online if the seller provides 24-hour support for application-related issues i.e. which material would be appropriate for the work, which settings would provide optimal results	Please indicate your level of agreement with the presented statement: 1 = strongly disagree 2 = disagree 3 = neutral 4 = agree 5 = strongly agree

Table 3.1. Survey Items (cont.)

Construct	Question Item	Response Options
Factors Influencing Online Purchase	*Post-Sales* 12) I would be more likely to buy a 3D printer online if the seller provides special discounts on other services i.e. market testing, prototype consulting	Please indicate your level of agreement with the presented statement: 1 = strongly disagree 2 = disagree 3 = neutral 4 = agree 5 = strongly agree
	Online Tools 13) I would be more likely to buy a 3D printer online if the seller provides a virtual tour of the showroom 14) I would be more likely to buy a 3D printer online if the seller provides a virtual product testing 15) I would be more likely to buy a 3D printer online if the seller provides an online chat service (human interaction) that can answer my questions 16) I would be more likely to buy a 3D printer online if the seller provides an online chat service (chatbot) that can answer my questions 17) I would be more likely to buy a 3D printer online if the seller has online media i.e. videos to guide me on how to install, use, and troubleshoot the printer	

Table 3.1. Survey Items (cont.)

Construct	Question Item	Response Options
Factors Influencing Online Purchase	*Product Attributes* 18) The brand of the 3D printer is an important factor for me 19) The price of the 3D printer is an important factor for me 20) The quality of the 3D printer is an important factor for me 21) The price of the 3D printing material is an important factor for me 22) The 3D printer needs to be easy to use	Please indicate your level of agreement with the presented statement: 1 = strongly disagree 2 = disagree 3 = neutral 4 = agree 5 = strongly agree
Purchase Intention	I intend to buy a 3D printer online for my next purchase (rather than offline)	
	Following the previous question, please explain why you would choose online over offline – or offline over online – for your next purchase of a 3D printer.	<open-ended>

3.4.2 Data Analysis

To explore and understand the relationship between the context of 3D printing use, factors for online purchasing of 3D printers, and behavioral intentions to purchase 3D printers online, multiple statistical analyses were performed on the collected data using the Statistical Package for the Social Sciences (SPSS) – a statistical software of top choice for academic and business fields alike (Arkkelin, 2014). As will be illustrated in the following chapter, the Kaiser-Meyer-Olkin (KMO) and Bartlett's test were conducted to first determine the suitability of the data and its structure for factor analysis (Shrestha, 2021).

An analysis of variance (ANOVA) for regression is then conducted, followed by a cross tabulation.

3.5 Procedure

The study recruited respondents via convenience sampling – that is, enlisting participants based on their ease of reach (Farrokhi & Mahmoudi-Hamidabad, 2012) while establishing a criteria that participants must have a background in the knowledge and/or experience of 3D printing technology. Data was collected online using a Google Form distributed to networks of acquaintances.

3.6 Ethical Considerations

The objective of the study was clearly outlined prior to participants' partaking in the survey. Given that the research question does not concern participants' demographics or identifiable data, information pertaining to participants' name, age, gender, or occupation was not requested.

CHAPTER IV
FINDINGS

The chapter outlines the present study's quantifiable results as achieved via statistical analyses – accompanied by narratives and implications of the findings for the Thailand 3D printing realm. The illustration and discussion of primary data is also performed in juxtaposition with the reflection of secondary data as examined during the review of the literature – solidifying or raising gaps in extant publications and contributing critical insights to the empirical field.

4.1 Respondents' Profile

Table 4.1. Respondents' Profile Categorized by the Context of 3D Printing Use

Context of 3D Printing Use	**Frequency**	**Percentage**
Business	104	66.7%
Leisure	27	17.3%
Education	25	16%
Total	**156**	**100%**

The survey received responses from a total of 156 participants – which have been screened for their self-reported knowledge or experience of 3D printing technology. The current study's sample is characterized predominantly by users of 3D printers in business contexts (66.7%), followed by leisure (17.3%) and education (16%) – implying

that the current state of Thailand's 3D printing technology is mostly applied for practitioners. Although a relatively small proportion of 3D printer users practice the technology for educational and learning purposes – which has previously been raised as a gap in the 3D printing industry (Harmon, Klein, Im, and Romero, 2022; Matias and Rao, 2015), the fact that a comparable segment utilizes 3D printers for leisure illustrates a promising future for Thailand as it indicates individuals' hedonic drive for using the technology (Halassi, Semeijn, and Kiratli, 2018).

4.2 Descriptive Statistics

Table 4.2. Descriptive Statistics for Factors Influencing Online Purchase (*n* = 156)

Factor	Item	Mean	Standard Deviation
Pre-Sales	To buy a 3D printer online, it is important for me to be able to ask questions and receive sufficient answers first	4.57	0.737
	To buy a 3D printer online, it is important for me to be provided a benchmark analysis of the work specification first i.e. accuracy, tolerance, strength	4.53	0.807
	To buy a 3D printer online, it is important for me to be provided an introduction or demo session by the seller first	4.39	0.899
	To buy a 3D printer online, it is important for me to be provided a test print sample/benchmark first	4.38	0.807

Table 4.2. Descriptive Statistics for Factors Influencing Online Purchase (*n* = 156) (cont.)

Factor	Item	Mean	Standard Deviation
Pre-Sales	To buy a 3D printer online, it is important for me to be provided some kind of bundle deal — such as a software subscription together with the purchase	4.11	0.981
	To buy a 3D printer online, it is important for me to be invited to a knowledge sharing session/event first	3.28	1.152
	Average total	**4.21**	**0.897**
Post-Sales	I would be more likely to buy a 3D printer online if the seller provides technical support at the store/service center — such that I can go to the store/service center for help	4.49	0.791
	I would be more likely to buy a 3D printer online if the seller can provide on-site technical engineer support — such that the staff can visit my office/house to troubleshoot the printer	4.33	0.953
	I would be more likely to buy a 3D printer online if the seller provides 24-hour support for application-related issues i.e. which material would be appropriate for the work, which settings would provide optimal results	4.30	0.868

Table 4.2. Descriptive Statistics for Factors Influencing Online Purchase (*n* = 156) (cont.)

Factor	Item	Mean	Standard Deviation
Post-Sales	I would be more likely to buy a 3D printer online if the seller provides special discounts on other services i.e. market testing, prototype consulting	4.30	0.807
	I would be more likely to buy a 3D printer online if the seller provides installation service	4.26	0.971
	I would be more likely to buy a 3D printer online if the seller provides workshops for me to learn new techniques	4.15	0.945
	Average total	**4.31**	**0.889**
Online Tools	I would be more likely to buy a 3D printer online if the seller has online media i.e. videos to guide me on how to install, use, and troubleshoot the printer	4.31	0.913
	I would be more likely to buy a 3D printer online if the seller provides an online chat service (human interaction) that can answer my questions	4.25	0.892
	I would be more likely to buy a 3D printer online if the seller provides a virtual product testing	4.06	1.005

Table 4.2. Descriptive Statistics for Factors Influencing Online Purchase (*n* = 156) (cont.)

Factor	Item	Mean	Standard Deviation
Online Tools	I would be more likely to buy a 3D printer online if the seller provides a virtual tour of the showroom	3.71	1.085
	I would be more likely to buy a 3D printer online if the seller provides an online chat service (chatbot) that can answer my questions	3.67	1.193
	Average total	**4.00**	**1.018**
Product Attributes	The quality of the 3D printer is an important factor for me	4.67	0.570
	The 3D printer needs to be easy to use	4.60	0.630
	The price of the 3D printer is an important factor for me	4.38	0.712
	The price of the 3D printing material is an important factor for me	4.34	0.775
	The brand of the 3D printer is an important factor for me	3.79	0.948
	Average total	**4.36**	**0.727**

4.3 Factor Analysis

Table 4.3. Kaiser-Meyer-Olkin (KMO) and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.844
Bartlett's Test of Sphericity	Approx. Chi-Square	807.497
	df	91
	Sig.	0.000

Table 4.4. Total Variance Explained (Extraction Method: Principal Component Analysis)

Component	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.108	36.484	36.484	3.536	25.256	25.256
2	1.455	10.393	46.877	1.875	13.391	38.648
3	1.248	8.917	55.794	1.868	13.340	51.988
4	1.078	7.699	63.493	1.611	11.505	63.493
5	0.878	6.269	69.762			
6	0.758	5.412	75.174			

Table 4.4. Total Variance Explained (Extraction Method: Principal Component Analysis) (cont.)

Component	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
7	0.724	5.171	80.346			
8	0.649	4.637	84.982			
9	0.480	3.431	88.414			
10	0.432	3.087	91.501			
11	0.408	2.915	94.416			
12	0.303	2.162	96.578			
13	0.273	1.949	98.527			
14	0.206	1.473	100.000			

As previously mentioned, the Kaiser-Meyer-Olkin (KMO) and Bartlett's test was implemented to assess the data's sampling adequacy for factor analysis (Shrestha, 2021). As suggested by Khandai, Agrawal, and Gulla (2015), the data showed a level of significance that exceeds 0.5 (the outcome value is 0.844) and a *p*-value of less than 0.001 (see *Table 5)* – indicating that there exists a relationship among the variables. The results also indicate that some of the components may be eliminated in order to identify the dimensions for the present study's understanding of factors influencing online purchases of 3D printers. As illustrated in *Table 6*, this was accomplished with the extraction method of principal component analysis; applied to all 14 components. Consequently, 10 components

which explained 63.5% of the model's variance were retained. Further, it can be observed that component 1 explained a notable proportion of the variance – specifically accounting for 36.5% and 25.3% of variance for the preserved components in the initial and rotated solutions, respectively. Accordingly the components deemed optimal for the present study's further analyses have been assorted into 4 main dimensions: 1) Technical and expert support from sellers, 2) Brand value, 3) Facilitative technology for online purchasing, and 4) Value-added promotions.

4.4 Regression

Table 4.5. Regression Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.482[a]	0.233	0.212	1.005	0.233	11.443	4	151	0.000
2	.481[b]	0.231	0.216	1.003	-0.001	0.268	1	151	0.605

a. Predictors: (Constant), ValueAddedPromotions, BrandValue, FacilitatingTechnologyForOnlinePurchase, TechnicalExpertSupportFromSeller

b. Predictors: (Constant), BrandValue, FacilitatingTechnologyForOnlinePurchase, TechnicalExpertSupportFromSeller

Table 4.6. Analysis of Variance (ANOVA)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	46.265	4	11.566	11.443	<.001[b]
	Residual	152.633	151	1.011		
	Total	198.897	155			
2	Regression	45.994	3	15.331	15.241	<.001[c]
	Residual	152.903	152	1.006		
	Total	198.897	155			

a. Dependent Variable: I intend to buy a 3D printer online for my next purchase (rather than offline)

b. Predictors: (Constant), ValueAddedPromotions, BrandValue, FacilitatingTechnologyForOnlinePurchase, TechnicalExpertSupportFromSeller

c. Predictors: (Constant), BrandValue, FacilitatingTechnologyForOnlinePurchase, TechnicalExpertSupportFromSeller

Table 4.7. Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.120	0.746		1.502	0.135
	TechnicalExpertSupportFromSeller	0.577	0.143	0.362	4.030	0.000
	BrandValue	-0.310	0.171	-0.141	-1.817	0.071
	FacilitatingTechnologyForOnlinePurchase	0.241	0.095	0.208	2.533	0.012
	ValueAddedPromotions	0.061	0.118	0.042	0.518	0.605
2	(Constant)	1.202	0.727		1.654	0.100
	TechnicalExpertSupportFromSeller	0.603	0.134	0.378	4.498	0.000
	BrandValue	-0.298	0.169	-0.135	-1.767	0.079
	FacilitatingTechnologyForOnlinePurchase	0.245	0.095	0.212	2.590	0.011

a. Dependent Variable: I intend to buy a 3D printer online for my next purchase (rather than offline)

Based on the results of regression analysis, it was found that three predictor dimensions – namely, technical and expert support from sellers, brand value, and facilitative technology for online purchasing – significantly accounted for 23% of the variance in participants' behavioral intentions to purchase 3D printers online, $F(3,152) = 15.24$, $p < .001$. In contrast, the dimension of value-added promotions was not a significant predictor of online 3D printer purchase intentions – $\beta = .04$, $p = .605$.

An examination of the mentioned three dimensions revealed that technical and expert support from sellers and facilitative technology for online purchasing were significant unique predictors of behavioral intentions – such that higher scores in these dimensions are associated with higher intention to purchase 3D printers online; $\beta = .38$, $p < .001$ and $\beta = .21$, $p < .05$, respectively. However, the unique contribution of brand value was less than 1% of the variance in intentions to purchase 3D printers online, $\beta = -.14$, $p = .079$.

Formulated based on the current study's primary findings, therefore, the suggestion for practitioners in the 3D printing industry is that the focus for market penetration should be the dimensions of technical and expert support offered to customers and the availability of technology to facilitate online purchasing. This is deemed to be in line with the observation of AMFG (2019), wherein both consumers and businesses are observed to be growing in terms of their eagerness for learning about 3D printing technology – an area of knowledge largely underdeveloped in Thailand (The Nation Thailand, 2022).

4.5 Cross Tabulation

Table 4.8. Cross Tabulation of Factors by Each Context of 3D Printing Use

Item	Context of 3D Printing Use	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Technical and Expert Support						
I would be more likely to buy a 3D printer online if the seller can provide on-site technical engineer support — such that the staff can visit my office/house to troubleshoot the printer	**Business**	2.9%	1.0%	10.6%	28.8%	56.7%
	Education	0.0%	4.0%	0.0%	40.0%	56.0%
	Leisure	7.4%	3.7%	11.1%	25.9%	51.9%
I would be more likely to buy a 3D printer online if the seller provides installation service	**Business**	2.9%	1.0%	6.7%	33.7%	55.8%
	Education	0.0%	0.0%	24.0%	40.0%	36.0%
	Leisure	11.1%	3.7%	11.1%	29.6%	44.4%

Table 4.8. Cross Tabulation of Factors by Each Context of 3D Printing Use (cont.)

Item	Context of 3D Printing Use	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Technical and Expert Support						
I would be more likely to buy a 3D printer online if the seller provides technical support at the store/service center — such that I can go to the store/service center for help	**Business**	1.0%	0.0%	7.7%	26.9%	64.4%
	Education	0.0%	0.0%	8.0%	28.0%	64.0%
	Leisure	7.4%	0.0%	3.7%	40.7%	48.1%
I would be more likely to buy a 3D printer online if the seller provides 24-hour support for application-related issues i.e. which material would be appropriate for the work, which settings would provide optimal results	**Business**	0.0%	0.0%	17.3%	27.9%	54.8%
	Education	0.0%	8.0%	16.0%	24.0%	52.0%
	Leisure	3.7%	3.7%	18.5%	25.9%	48.1%

Table 4.8. Cross Tabulation of Factors by Each Context of 3D Printing Use (cont.)

Item	Context of 3D Printing Use	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Technical and Expert Support						
I would be more likely to buy a 3D printer online if the seller provides workshops for me to learn new techniques	**Business**	1.0%	2.9%	17.3%	30.8%	48.1%
	Education	0.0%	4.0%	20.0%	44.0%	32.0%
	Leisure	7.4%	0.0%	22.2%	25.9%	44.4%
I would be more likely to buy a 3D printer online if the seller has online media i.e. videos to guide me on how to install, use, and troubleshoot the printer	**Business**	1.0%	3.8%	9.6%	29.8%	55.8%
	Education	0.0%	0.0%	16.0%	44.0%	40.0%
	Leisure	7.4%	3.7%	3.7%	33.3%	51.9%
Technology to Facilitate Online Purchasing						
I would be more likely to buy a 3D printer online if the seller provides a virtual tour of the showroom	**Business**	1.0%	9.6%	20.2%	37.5%	31.7%
	Education	0.0%	16.0%	32.0%	36.0%	16.0%
	Leisure	18.5%	7.4%	29.6%	29.6%	14.8%
I would be more likely to buy a 3D printer online if the seller provides a virtual product testing	**Business**	0.0%	8.7%	8.7%	38.5%	44.2%
	Education	0.0%	8.0%	20.0%	44.0%	28.0%
	Leisure	11.1%	7.4%	11.1%	40.7%	29.6%

A cross tabulation analysis of the two dimensions identified as significant predictors of online 3D printer purchase intentions was performed. For the dimension of technical and expert support, referring to *Table 10,* it can be seen that users of 3D printers in business contexts tend to place the highest importance on the availability of technical support at the store or service center – followed by on-site technical support and installation services. A similar trend was observed among 3D printer users for education purposes – particularly that providers' technical support in-store or at the service center was evaluated to be the most impactful factor in leading to purchase intentions, followed by the same provision but on-site. Contrary to business-related users of 3D printers, educational users' third most important factor is the availability of 24-hour support for issues pertaining to the application of 3D printing technology. Interestingly, the group expressed relatively less strong preference for sellers' installation services. Moreover, the least strong factor for educational users is identified to be sellers' provision of workshops for learning new 3D printing techniques. With respect to leisure 3D printing users, the most important factors are on-site technical support and online media to guide 3D printers' installation, use, and troubleshooting. The third most prioritized factor for these leisure users is the availability of technical support at the store or service center.

With a particular attention to the dimension of facilitative technologies for online purchasing, it was found that a virtual product testing of 3D printers is a powerful factor influencing purchase intentions for 3D printing users regardless of the context for application. A virtual tour of the sellers' showroom, on the other hand, is not particularly prioritized in comparison.

CHAPTER V
CONCLUSION

5.1 Recommendations

In accordance with the obtained findings, it can be conjectured that the market of Thailand's 3D printing users comprise 3 primary groups depending on the context of usage: business, education, and leisure. Corresponding to this categorization, the present study's analyses led to the suggestions for practitioners – particularly with respect to potential online distribution of 3D printers – as illustrated in the table below:

Table 5.1. Managerial Implications for Unique Contexts of 3D Printer Use

Context of 3D Printer Use	Managerial Implications
Business	- Users/potential consumers tend to prioritize sellers' provision of technical support at the store and/or on-site - The provision of installation services is also a notable aspect of consideration - The availability of facilitative technologies, especially a virtual product testing, is an important decision factor
Education	- Users/potential consumers tend to prioritize sellers' provision of technical support at the store and/or on-site - The provision of 24-hour support for users in addressing issues related to 3D printing applications is also a notable aspect of consideration - For this group, installation services are not as important

Table 5.1. Managerial Implications for Unique Contexts of 3D Printer Use (cont.)

Context of 3D Printer Use	Managerial Implications
Education	- The availability of facilitative technologies, especially a virtual product testing, is an important decision factor
Leisure	- Users/potential consumers tend to prioritize sellers' provision of technical support at the store and/or on-site - The provision of educational online media is also a notable aspect of consideration - The availability of facilitative technologies, especially a virtual product testing, is an important decision factor

All in all, it is advised that sellers of 3D printers focus on technical and expert support; specifically providing the service in-store or at a service center for customers' walk-in or appointment-based requests for support. To drive users' online purchase, it is recommended that practitioners offer virtual testing of 3D printers – which is anticipated to effectively address consumer concerns of their limited experience with 3D printers, as the primary results have indicated. Beyond the findings attained from quantifiable responses, participants have also added explanations for their reluctance to purchase 3D printers online as opposed to offline – commonly pertaining to the product-related details and clarifications necessitated prior to making purchase decisions. Therefore, demonstrations of 3D printer use as well as knowledge sharings are anticipated to alleviate consumers' concerns. In other words, sellers' expert support and guidance are highly crucial for tackling the market of 3D printer users. Further, as dimensions of brand value and value-added promotions were deemed insignificant predictors for purchase intentions, practitioners may compromise high price points or lack of other product value-related aspects for the mentioned offer of know-how.

5.2 Conclusion

Revisiting the current study's research objectives, it can be concluded that the current state of Thailand's 3D printing realm is characterized predominantly by the use of 3D printers in business contexts. The challenges from the view of practitioners, as the findings have unveiled, pertain to the high level of expert support for 3D printer consumers – as factors identified to have significant importance are observed to hinge particularly on sellers' technical facility and specialist service. On a related note, opportunities for practitioners in Thailand's 3D printing industry concern the potential viability and success of online sales provided the availability of expert staff support and technology that eases consumers' efforts to understand the product's mechanism.

Regardless of the insights yielded, the present study is not without its gaps necessitating the attention of subsequent research. Specifically, the implementation of quantitative methods alone has restricted the conclusions to pre-defined frames of responses while the perspective and experience of 3D printer users – along with their view on online purchasing – are found to be unique and subjective with directions beyond those suggested by practitioners and consumers during the preliminary interviews. Accordingly, future research with more resources should integrate both quantitative and qualitative approaches in order to contribute richer insights to a largely understudied market of 3D printing in Thailand.

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APPENDICES

Appendix A. Preliminary Interview Notes

Participant 1 - Practitioner in 3D Printing

Background	Interviewee is an experienced practitioner in 3D printing; experienced in overseeing a 3D printing community that hosts workshops and develops online knowledge sharing content, provides 3D printing services, and sells 3D printers both offline and online. The business originated with the objective of "localizing" manufacturing – in such a way that consumers are empowered with the knowledge, ability, and craftsmanship to develop their own products.
Perspective on 3D Printing in Thailand	Interviewee perceives Thais as comprising 2 groups of people: those that can only ideate and those that can only create. Sees 3D printers as a tool that can enable both these groups. Interviewee thinks that the "trend" of 3D printing among consumers had already passed – sees that the hype had already peaked and dropped. Based on the interviewee's observation, people who usually buy 3D printers to "play with" tend to use the technology for up to a year.
Perspective on the 3D Printing Market	Interviewee sees that the segments of 3D printers consumers are as follows: - Makers (those with an intrinsic drive to build their own stuff) - Hobbyists (these are the people that are buying 3D printers now) - Newbies (want things or parts that cannot be bought, but does not yet have the technical knowledge to maneuver 3D printers – however will eventually save up to purchase them) Sees "newbies" as the target group if they can pass the knowledge barrier. These individuals have an inclination for designing and printing – motivated/inspired by the concept of 3D printing (i.e. "anything" can be printed). Some print parts for board games and sell these board games. The interviewee also operated a service for prototyping and market testing – utilized 3D printing for small scale manufacturing. Sees that this is a business that can bring revenue. The interviewee operated a membership-based 3D printing community but does not think that this is a viable business model as 3D printers require high investment costs and Thais' preference do not align with

	membership payments for services i.e. Thais do not think it is worth it to pay expensive monthly costs for membership. The business model works in other countries as they receive high funding. The interviewee sees that operating an education-based business model would be most optimal for the current market. The interviewee sees that the target group of 3D printers varies. For B2C, the target group would be those who are looking for a shift in their career (i.e. wants to become a designer). However, B2B is more profitable as 3D printers are becoming more prevalent in Thailand's manufacturing sector especially in ceramics. Sees that 3D printing businesses can also generate revenue from providing training sessions i.e. to designers, operators, manufacturing staff, etc.
Insights on Selling 3D Printers	3D printers do generate revenue – the Thai market is buying 3D printers. The interviewee operated an online channel – spent great efforts in developing the website, SEM, keywords, and content (no advertisements). The website design process took a long time – the interviewee extensively studied the target group's consumer behaviors. Sees that after sales service is what distinguishes the business from other sellers – providing support in installation, troubleshooting, etc. However, this requires a great deal of time and effort as staff will need to always talk to clients and advise them; sometimes driving to their house to attend to the printers. Need to have technicians on stand by. The interviewee thinks that both online and offline channels need to be operated – from the interviewee's experience, only a few people would complete the purchase via website only. Especially as Thai people prefer to see the products and ask questions prior to making a decision. The interviewee also created a Line group for potential and existing customers to talk directly with makers. It needs to be ensured that customers can reach out to the staff as conveniently as possible. One of the challenges is that, given 3D printers are imported, if one small part of the printer is lost or broken it takes time to order and have it shipped from abroad (cannot find alternatives). A strategy that would really work is to be a sole distributor of a 3D printing brand – but the volume would need to be high.

Participant 2 - Practitioner in 3D Printing

Background	A General Manager of a company that sells 3D printers (offline) and operates a service bureau. Oversees 6-7 companies in APAC but is based in Thailand.
Perspective on 3D Printing in Thailand	Interviewee personally sees the future of 3D printing as quite bright – as soon as it kicks in that students are appropriately trained.
Perspective on the 3D Printing Market	Observes that store-based selling of 3D printers for metal and plastic is very scarce. Lower-end 3D printers typically used for hobbies probably have more store-based sellers (but the interviewee does not have any insights on this). Sees that the selling of higher-end 3D printers (i.e. powder-based plastic printers) is growing but not at the ideal speed. The target group for small printers (not industrial) would be families or people who are using 3D printing technology as a hobby. The target group for high-end printers would be bigger companies ready to invest in technology. Perceives that the Thai market is ready to make 3D printer purchases online – particularly for low-end 3D printer users that know what they want. Sees that 3D printers do not need to be sold offline where a sales meeting and/or service contract are required.
Insights on Selling 3D Printers	Sees that the challenges in operating 3D printing businesses are similar to any other business – if the products or services are in demand, then there are less issues. 3D printing is not a new technology but the industry is underdeveloped given gaps in design education i.e. training at the university level. Suggestions for online selling for an exclusive distributor would be a focus marketing activities i.e. YouTube channel leading to the business name. If the business is not an exclusive distributor then it is challenging as customers can select other sellers with lower price points. If this is the case, then the focus should not be on building up the marketing. Another suggestion is that the process of ordering and delivering must

	be ensured of its convenience and ease for the customers. The challenges might be for selling higher-end printers where a sales meeting needs to be held prior to purchase, also if customers have questions that might be difficult to answer online. However if the customers already know what they want, they will go online and seek for cheaper prices.

Participant 3 - User of 3D Printers

Background	A product design student familiarized with the principles as well as use of 3D printers.
Perspective on 3D Printing in Thailand	Sees potential for 3D printing to grow among design students or practitioners whose work necessitates prototypes. However, does not think that 3D printers will become a household item for laymen to utilize as hobbies or for fixing objects. Feels that the current Thai market does not recognize the advantages of 3D printers beyond its expensive cost (compared to simply buying parts or products that are currently in the market).
Relationship with 3D Printers	As a design student, the interviewee often uses 3D printers for projects as it saves time and provides more accurate results (as opposed to developing models manually). Some other students buy 3D printers so other students basically just borrow their printers for use. The interviewee expressed an intention to buy a 3D printer but would like to invest in more high-end ones rather than cheap ones.

Participant 4 - User of 3D Printers

Background	A service bureau that uses 3D printers to support customers' parts in different industries such as prototyping, spare parts, and end-used parts.
Perspective on 3D Printing in Thailand	The interviewee feels that 3D printers nowadays are more easy to access and the prices are more reasonable, than before. Therefore, the interviewee foresees the trend of increasing household manufacturers who use 3D printers to produce and design the products which may lead to the new kind of business opening.

Relationship with 3D Printers	As a user, the interviewee often uses 3D printers for service bureau printing prototypes, spare parts, and end-used parts as it saves time and provides more accurate results. With the perspective of 3D printer technology is more likely a copier or paper printer which makes the ideas come out into reality and more tangible. The interviewee expressed an intention to buy a 3D printer but will explore the reviews through the internet before deciding to buy in storefront.

Participant 5 - User of 3D Printers

Background	A product design engineer uses 3D printers for research and development in the electronic industry.
Perspective on 3D Printing in Thailand	In Thailand, 3D printers are still widespread in a specific group of users, mainly in the developer sector where the interviewee sees that its quite difficult to achieve such a high growth in 3D printer in Thailand. Moreover, there is some limited technology in 3D printer that still cannot be achieved in mass production segment
Relationship with 3D Printers	From the interviewee's view, the equipment that can easily convert from CAD files to solid objects, is the best thing for engineers. Because the engineer can produce the real parts by using 3D printer and test it right away to see the outcomes. As if the development goes faster, it can save cost, time as well as other resources, which is the main concern for business owners. The interviewee expressed an intention to buy a 3D printer with the concerned of reasonable price as well as intend to buy on online channel if the sellers can provide lots of tutorial videos.