Vol. 19 No. 3 May -- June 2024

Interdisciplinary Research Review

ISSN 2697-536X (Online)

Interdisciplinary Research Review

Publisher : Editorial Office of Interdisciplinary Research Review, Interdisciplinary Committee for Research and Development, the Royal Society of Thailand

Origin : The Interdisciplinary Research Review was established with the cooperation of four institutes:
1. The Royal Society of Thailand Committee of Interdisciplinary Research and Development
2. Phetchaburi Rajabhat University
3. Interdisciplinary Research Foundation
4. Kanchanaburi Rajabhat University

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Editorial Note

The Interdisciplinary Research Review (IRR) was established with academic cooperation by The Royal Society of Thailand Committee of Interdisciplinary Research and Development, Rajabhat University (Western Group), and Rajamangala University of Technology Rattanakosin. This Issue, Volume 19 Number 3 (May – June 2024). This issue contains of four interesting articles in multidisciplinary fields: (1) The characteristics of vacuum fried pineapple cores (Ananas comosus) as affected by processing conditions: effect of time and temperature conditions, (2) An Alternative Statistical Approach for the DOE with the Attribute Response , (3) The Development of Online Reading Lesson by Using Metacognitive Strategies of Thai Undergraduate Students , (4) The development model of internal supervision management according to standards of the early childhood education schools under the Office of the Basic Education Commission

The Editorial Board of the IRR encourages anyone to submit articles for evaluation and review. The processes of submission, review and publication of articles are described on the journal's website, https://www.tci-thaijo.org/index.php/jtir. The Editorial Board and Committees of the IRR sincerely thank all peer reviewers who have sacrificed their time to help us produce a better journal, and also wish to thank all teachers, researchers and other academicians for submitting their valuable research to this journal. Finally, we thank readers of our journal who help to spread the knowledge and benefits gained to others. With your feedback and suggestions, we will strive to improve the quality and relevance of the IRR.

Yongyudh Vajaradul
Editor
Interdisciplinary Research Review

Interdisciplinary Research Review
Volume 19, Number 3, Pages 1 – 12

The characteristics of vacuum fried pineapple cores (*Ananas comosus*) as affected by processing conditions: effect of time and temperature conditions

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Abstract

The effect of frying temperature and time on the characteristics of vacuum fried pineapple cores was studied. The finding demonstrated that the severe frying conditions had a significant ($p \leq 0.05$) impact on moisture content, oil uptake, color, texture, expansion, microstructure and sensorial evaluation. A rise in frying temperature and time was inversely linked with the moisture content (10.76 to 3.17%) and hardness value (341.28 to 72.09 g). Whereas, it positively affected on a significant increase in oil absorption (15.00 to 19.97%), expansion (20.23 to 50%), color, pore structure and overall acceptability. The optimal conditions for vacuum frying pineapple cores to obtain the greatest texture and golden yellow color, and achieve the best score (5.13 to 6.20 out of 7) in all sensory aspects, was 80°C frying for 90 minutes. It could be a potentially alternative to create snacks not only helps reduce food waste but also contributes to sustainable efforts, aligning well with the Sustainable Development Goals (SDGs).

Keywords: vacuum frying, pineapple, pineapple core, microstructure, dietary fiber

Article history: Received 08 January 2024, Revised 29 April 2024, Accepted 29 May 2024

The pineapple (*Ananus comosus*), one of the world's most important agricultural fruits, is produced in more than 10 million metric tons globally [1]. It is a rich source of phenolic bioactive compounds, dietary fiber and essential minerals like manganese and copper. The presence of phenolics in pineapple contributes to its potent antioxidant activity, which is vital for combating oxidative stress and reducing the risk of chronic diseases. Additionally, the high fiber content and bromelain in pineapple promote digestive health by supporting regularity and aiding in nutrient absorption. Therefore, the consumption of pineapple has health benefits, namely on the digestive system and helps to maintain a balanced diet [2-3]. Generally, during the pineapple processing, approximately 50% (w/w) of the total pineapple weight was co-products (29–40% shell, 9–10% core, 2–6% stem, and 2–4% crown) [4-5]. As the matter of facts, there are a variety of nutritional values, including dietary fiber, vitamins, minerals, phenolic compounds and other bioactive compounds are presented in the co-products [2]. It, therefore, has the potential to be transformed into value-added products. Utilizing agro-industrial co-products from pineapple processing not only helps to diminishing waste but also creates opportunities for producing value-added products.

Drying and dehydration are well-known techniques for removing moisture and enhancing the shelf life of the agricultural product, particularly perishable fruit and vegetables [6]. Among them, the frying process is a potential alternative strategy to decrease water and extend shelf life of the final products. In particular, deep fat frying is a common method that not only preserves but also adds value to fruits and vegetables. Even though a

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deep fat frying is very popular method but it is applied to a small number of materials such as potato and banana. This might be due to its high temperatures can degrade nutrients and lead to excessive oil absorption [7]. One of the newest possible ways to process fruit and vegetables with less oil consumption while maintaining desired texture and flavor characteristics is vacuum frying.

Vacuum frying occurs under low pressure, while deep- or shallow-frying is done under the atmosphere pressure. So, it is processed at a lower temperature than deep- or shallow-frying. Water then is removed at a lower boiling degree, and product quality is superior in terms of oil content, texture and nutrient retention [8]. Vacuum frying presents promising benefits, such as producing healthier fried foods with lower oil content and better retention of nutrients and flavors compared to conventional frying methods. It's worth nothing that the technique may require specialized equipment and careful process control to achieve optimal results [9]. However, as consumer demand for healthier food options, vacuum frying holds significant potential for the food industry as a method to produce nutritious and flavorful fried products. Numerous studies have examined the impact of vacuum frying on a variety of foods, including shitake mushrooms, papaya, bananas, sweet potatoes, cassava and pineapple chips [6, 10–15]. Additionally, they determined the structure of final products on the outside and inside, texture, water and oil content by varying vacuum frying condition. However, none has investigated how vacuum frying impacts the quality of high fiber fruit and co-product from the industrial segment such as the core of pineapple. Therefore, the purpose of this study was to investigate the effects of frying conditions, particularly temperature and time, on the quality of pineapple cores. Pineapple cores are often discarded as waste in food processing, so finding ways to utilize them effectively well with the principles of the bio-circular-green (BCG) economy model. This approach emphasizes sustainability by integrating scientific innovation and technology to create value from biological resources, strengthening Thai BCG industries while minimizing environmental impact [16].

2. Materials and methods

2.1. Material

The pineapple (*Ananas comosus*) was cultivated and obtained from The Farm Marketing state-owned enterprise (Ratchaburi, Thailand). It was selected at the ripening stage of 20-30% with a soluble solids concentration of 13-14 ^{o}Brix. The pineapple cores, a leftover or co-product from pineapple juice processing, were sliced in the longitudinal direction at 1×5×0.1 cm and kept in the refrigerator at 4^{o}C until further processing.

Frozen pineapple juices were obtained from The Farm Marketing state-owned enterprise (Ratchaburi, Thailand). The total soluble solid of frozen pineapple juice was controlled at 30±2 °Brix.

2.2. Pineapple core preparation

Pineapple cores were immersed at a ratio of 1:1 in 30 ^{o}Brix pineapple juices at the temperature 20±3^{o}C until the soluble solid in the sample reached 20±1°Brix. Then the pretreated pineapple cores were drained and frozen at -25 ^{o}C for three hours (March cool, 2 0 0 9 model, Thailand). After being frozen, from the preliminary studied, the pineapple cored were vacuum fried at the selected temperatures of 70,75 and 80^{o}C (700 mmHg) for the selected time of 50, 60, 70, 80 and 90 min. Extreme conditions of temperature and time gave a rejection from the sensory aspects (data not shown). Each batch of frozen pineapple cores, 700-800g of samples, was afterward fried in 20 liters of palm oil. After frying, the products were centrifuged for 20 min at 900 rpm to get rid of surplus oil and lower the oil content. The moisture and oil content were measured at each temperature for each time in triplicate according to AOAC [17].

2.3 Texture analysis

The texture of vacuum fried pineapple cores was analyzed using a Texture analyzer (TA. XT plus, UK). The sample was placed on a hollow planar base. A spherical probe of P0.5 was set to a test speed of 10 mm/s at a distance of 5mm or until the sample cracked. The maximum force from the force deformation curve of each sample was considered as hardness (g) [12].

2.4 Expansion measurement

The fresh and vacuum samples were measured the thickness by the Vernier caliper (0.05 mm precision). The percentage of expansion was described by Yamsaengsung et al [10] as follows

$$\%\ expansion = 100 \times \frac{D-D0}{D0}$$

Do is the original thickness of fresh samples

D is the end of each thickness of the vacuum fried sample

2.5 Color measurement

The color analysis was carried out with a colorimeter chroma meter (Minolta CR310, Japan) using the CIE standard (L*, a*, b*). The CIE values of L* represent the range of dark to light color, a* represent the range of green to red color, and b* represent the range of blue to yellow color [18].

2.6 Microstructure

The oil content in products prepared in section 2.2 was eliminated by the Soxhlet extraction method [15]. The deoil dried samples were cut and mounted on an aluminum stub, and then coated with gold. The microstructure of the samples was examined using a scanning electron microscope (SEM) (Tescan Mira3, Czech Republic) at a 100x magnification and 15kV accelerated voltage [19].

2.7 Sensorial evaluation

The sensory evaluation for consumer acceptance testing was performed by 30 untrained panelists, aged between 20-45 year old. All panelists were familiar with this kind of pineapple without allergies. The 7-point hedonic scale questionnaire (1 = dislike extremely, 7 = like extremely) was used to evaluate the test of the vacuum fried samples. Test attributes were appearance, color, crispiness, flavor and overall acceptance of the product. The appearance of the final products is shown in Figure 1.

2.8 Dietary fiber, total starch and resistant starch measurement

Dietary fiber was analyzed by the in-house method TE-CH-076 based on AOAC [17]. Total starch and resistant starch of the samples were measured by glucoamylase methods [20] and determined using Megazyme kits (Megazyme International Ireland, Ireland). Fresh and vacuum fried samples were conducted.

2.9 Statistical analysis

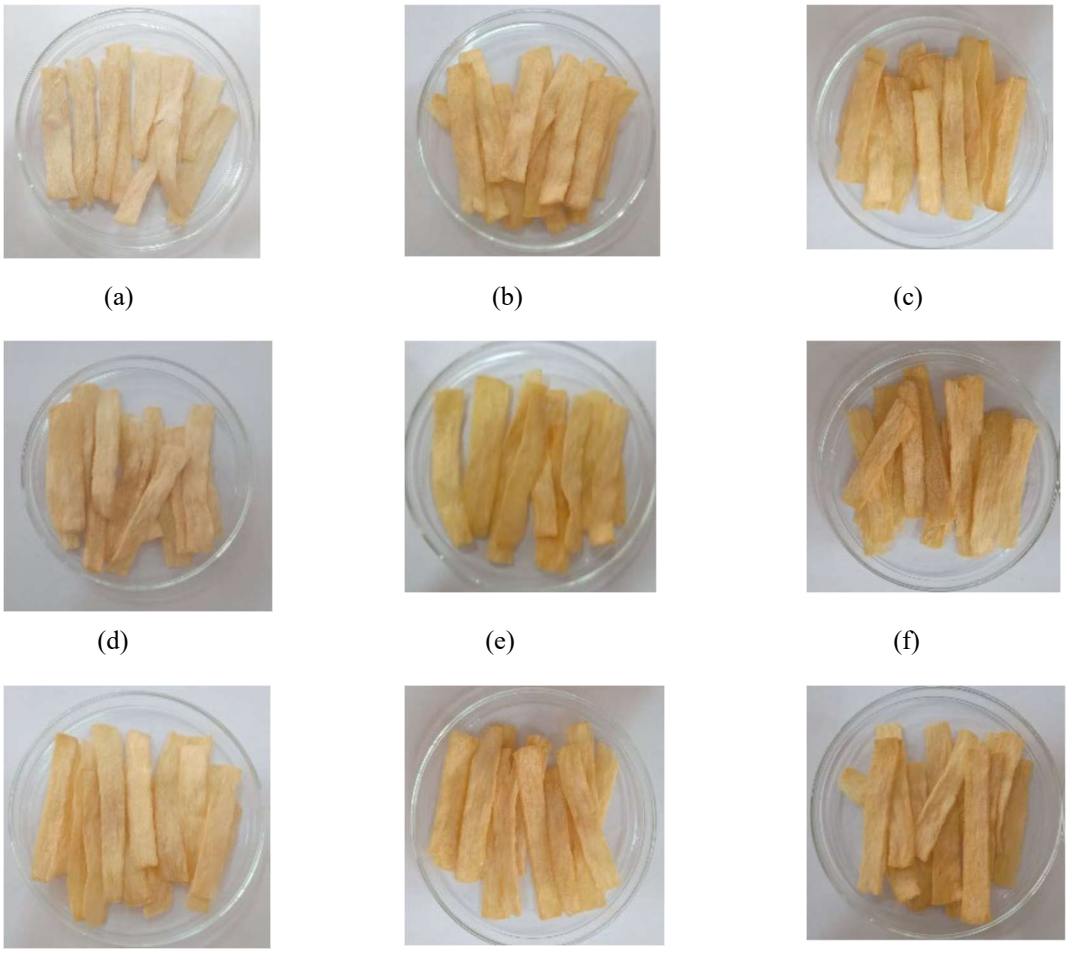
A factorial in complete randomized design 3x5 was applied to experiments related to the physical properties. A randomized complete block design was used for the sensory test. The data analysis of variance was performed and the difference among means was conducted by Duncan's new multiple ranges test at the 95% significant confidence interval. SPSS software version 23 was carried out all statistical analysis (IBM, USA).

3. Result and discussion

3.1 Moisture and oil content

The data presented in Figure 2 clearly shows the impact of varying frying temperatures and times on the oil and moisture content of pineapple cores. It was obvious that the temperature increases from 70 to 80°C and the frying time extends from 50 to 90 minutes, there's a noticeable decrease in moisture content. Simultaneously, there was a significant rise in the oil uptake by the pineapple cores ($p \leq 0.05$). The moisture content of pineapple cores was varied between 3.17 to 10.76%. During vacuum frying, moisture migrates more quickly from interior to the food surface. At the initiate state, lower frying temperatures (70°C) resulted in less water loss from the sample than that of high temperatures (80°C). The results demonstrated that higher temperatures and longer frying durations lead to more efficient dehydration or more water was evaporated from the samples. The findings of this study indicated a tendency toward rising oil uptake, with values between 15.00 and 19.97%. The high amounts of oil uptake may be the result of moving into the product pore spaces through capillary channels formed due to moisture evaporation, both on the surface and inside, which led to increased oil penetration from the driving force [21-22]. The coefficient

correlation (R^2) of oil absorption and water evaporation during vacuum frying was 0.73 at 70°C, 0.82 at 75 °C and 0.93 at 80°C. The results related to study of Su et al (2016) [13] who reported that under intense frying at high temperatures (100, 110, and 120 °C) and for long periods of time (0 to 10 min), that the oil content of potato chips increased while the moisture content decreased.



(a) (b) (c)

(d) (e) (f)

(g) (h) (i)

Figure 1. The appearance of the pineapple cores prepared by vacuum frying at 70 °C (a, d, g), 75 °C (b, e, h) or 80 °C (c, f, i) for 50 min (a, b, c), 80 min (d, e, f) or 90 min (g, h, i).

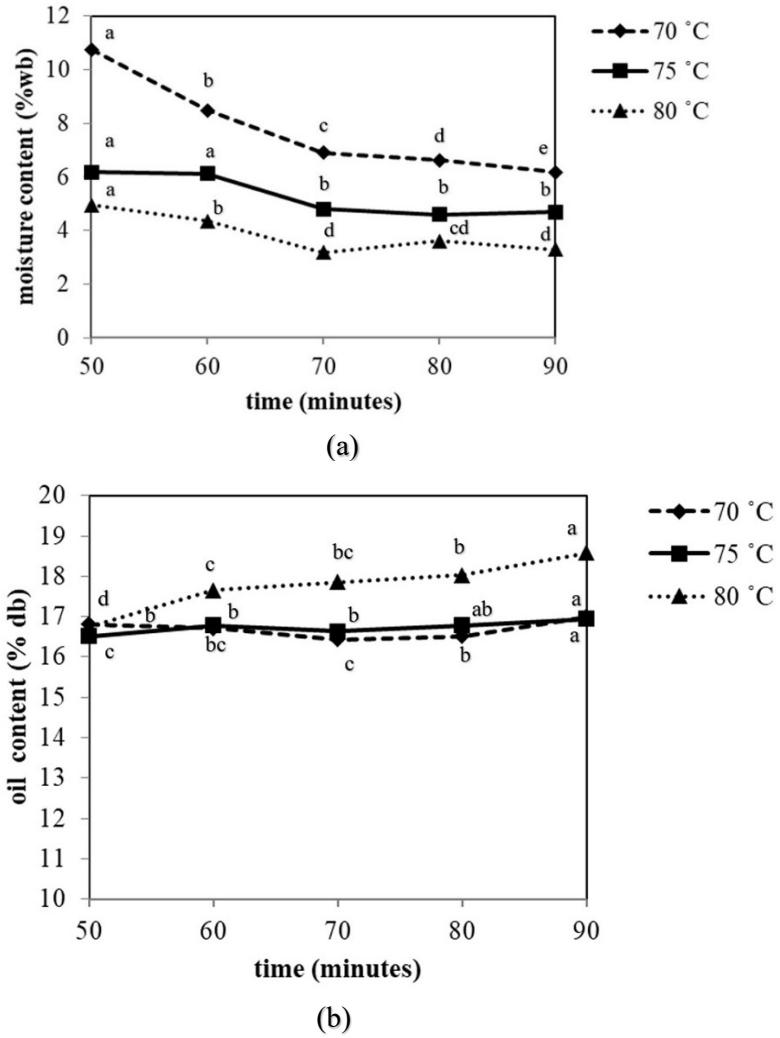


Figure 2. Moisture (a) and oil content (b) of the vacuum fried pineapple cores at various temperatures and time conditions.

3.2 Hardness and expansion

The quality of fried products is generally affected by the frying conditions, the thickness of the products, the properties of food stuff and the desired final products especially the textural of the product [10, 21]. The breaking force can be used as an indicator of the crispiness of products. In the early stage of frying, the moisture in samples is high and the texture is then tough, with lower breaking force or hardness value indicating higher crispiness [12]. From Table 1, the hardness value tended to decrease as the frying temperature and time increased ($p \leq 0.05$). Consequently, the hardness value decreased from 341.28 g at 70ºC frying for 50 minutes to 72.09g at 80ºC frying for 90 minutes. Additionally, the expansion values increased under more severe frying conditions, reaching a maximum of 50% at 80°C frying for 90 minutes. According to Esan et al [11] who found that increasing oil temperature and frying time affected the texture of yellow-fleshed sweet potatoes, leading to rapid hardness changes, accelerated crust formation, and ultimately decreased hardness values. This phenomenon can be attributed to the evaporation of gases from the products during frying, which creates a porous structure and results in increased product expansion, as depicted in Figure 4. Similarly, Yamsaengsung et al [10] observed a similar effect in banana chips subjected to vacuum frying at 110°C for 20 minutes at 8 kPa. The chips exhibited a significant increase in pore size, leading to the highest volume expansion of over 20%

Table 1. Hardness and percentage of expansion of vacuum fried pineapple cores at various temperatures and time conditions.

Sample no.	Temperature (°C)	Time (min)	Hardness (g)	Expansion (%)
1	70	50	341.28^{a}±12.66	20.23^{e}±2.83
2		60	318.07^{a}±19.92	22.00^{e}±1.18
3		70	320.07^{a}±15.56	24.92^{de}±3.14
4		80	254.50^{bc}±27.17	30.98^{d}±5.66
5		90	158.17^{de}±17.36	40.32^{b}±1.07
6	75	50	273.20^{b}±16.22	30.17^{d}±8.01
7		60	226.61^{c}±32.83	35.00^{c}±2.07
8		70	167.87^{d}±16.74	35.17^{c}±3.17
9		80	150.07^{de}±20.80	45.07^{ab}±6.10
10		90	136.60^{e}±12.15	45.00^{ab}±6.12
11	80	50	190.51^{cd}±17.62	35.00^{c}±2.14
12		60	144.44^{e}±14.84	45.07^{ab}±6.11
13		70	128.42^{f}±37.38	50.00^{a}±9.22
14		80	112.49^{f}±16.51	50.00^{a}±6.93
15		90	72.09^{g}±4.93	50.00^{a}±7.07

$^{a,b,\cdots}$Mean values with different letters in the same column were significantly different ($p \leq 0.05$).

3.3. Color

The changes in color of vacuum fried samples were observed L* (lightness), a* (green-red chromaticity) and b* (blue-yellow chromaticity). Figure 3 shows the effects of frying time and temperature on the color of pineapple cores. The color values of the pineapple cores in the current study for all conditions ranged from 68.46 to 79.93 (L*), 0.93 to 2.84 (a*) and 20.63 to 24.57 (b*). The statistical analysis demonstrated that raising the frying temperature and time had a significant ($p \leq 0.05$) impact on the color values of samples. Higher conditions could reduce the L* value while accelerating the a* and b* value, resulting in the better desirable golden color of pineapple cores development (Figure 1). The color change that occurred during severe frying conditions could be attributed to the chemical oxidation and carbohydrate degradation [23]. The reactions that contribute to the browning of fried foods are partly due to the Maillard reaction, a complex series of reactions between amino acids and reducing sugars [13, 21]. Pineapple cores, containing 0.1% proteins and 4.3% carbohydrates [24], provide the potential material for Maillard reactions to occur during frying [22]. These reactions not only alter the color of the food but also play a significant role in developing its flavor and aroma, enhancing the overall sensory

experience of the fried products [23]. Similarly, the studied of Wanakamol & Poonlarp [15] reported that the pineapple chips were fried at 90-95 °C for 50-60 min under depressurized to 60 mmHg showed a significant impact on the lightness (from 64.21 to 55.92) and hue value (from 81.36 to 77.16) as darker color can be seen in more intense process.

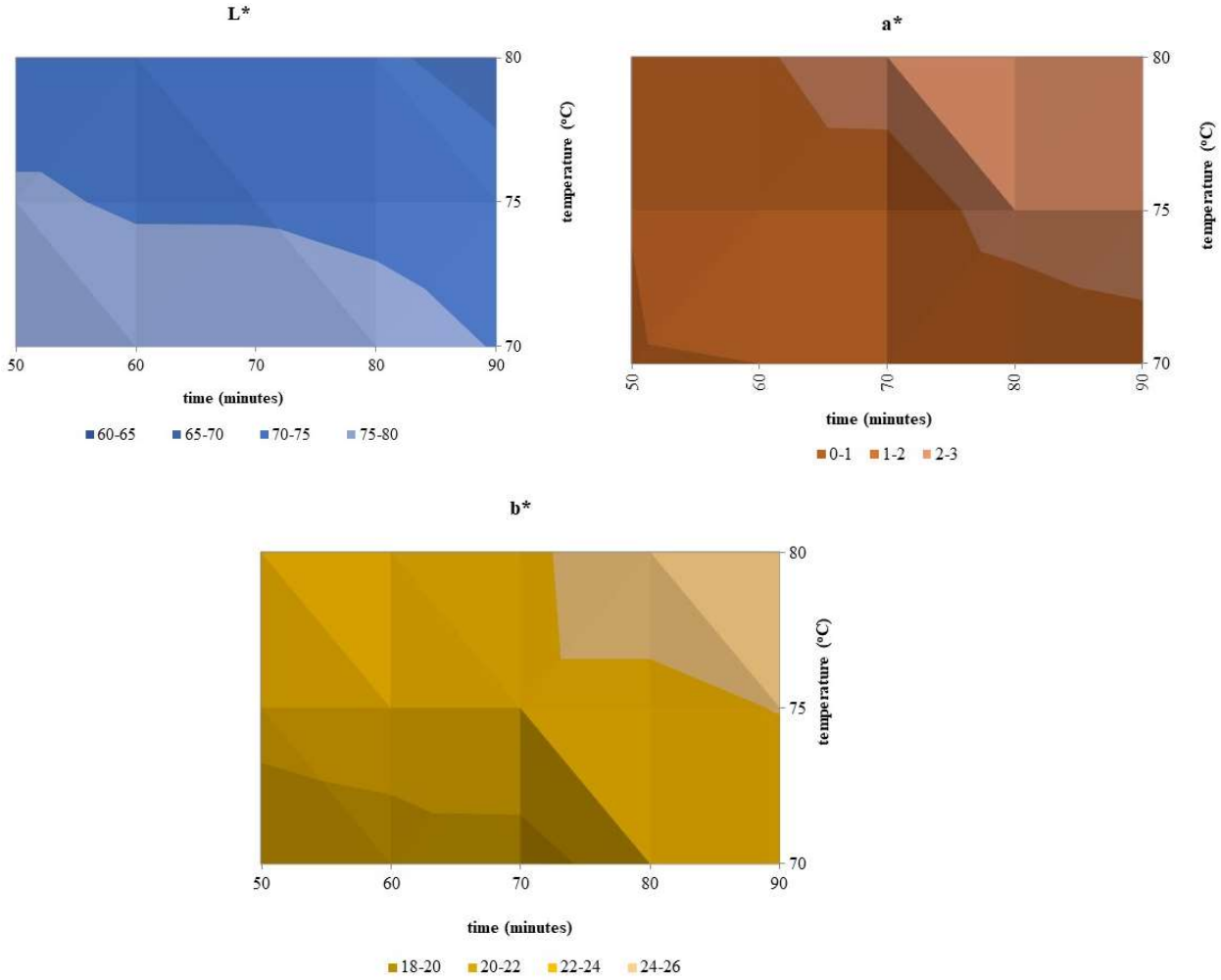


Figure 3. CIE (L*, a*, b*) color of pineapple cores were prepared by vacuum frying at 70, 75 and 80 °C for 50, 60, 70, 80 and 90 min.

3.4. Microstructure

The study investigated the structural changes in vacuum-fried pineapple cores, particularly focusing on the microstructure alterations concerning frying temperature and time as shown in Figure 4. It was observed that both the number and size of pores within the samples increased progressively with higher frying temperatures and longer frying times. This phenomenon was attributed to the removal of free water from the cellular structure during the frying process. Before frying, the pineapple cores underwent pretreatment by being frozen at -25°C. The formation of ice crystals during freezing initially damaged the plant tissue. Subsequently, upon heating, these ice crystals within the frozen cells sublimated under vacuum conditions, leaving behind pores in the food matrix. As a result, a porous sponge-like structure was formed [25]. The findings of this study was consistent with previous researches on the microstructure of vacuum-fried potato and sweet potato [11-12]. These two studies reported that vacuum frying at

90°C induced the formation of a sponge-like pore effect in the fried samples. Similar to the findings with pineapple cores, both the number and size of pores within the product increased with higher frying temperatures and longer frying times. These results strongly support the hypothesis that internal water vapor expansion within the product leads to thickness expansion, as outlined in Table 1. Consequently, the samples exhibited the lowest hardness values, indicating greater crispiness, after exposure to high temperatures and longer frying times.

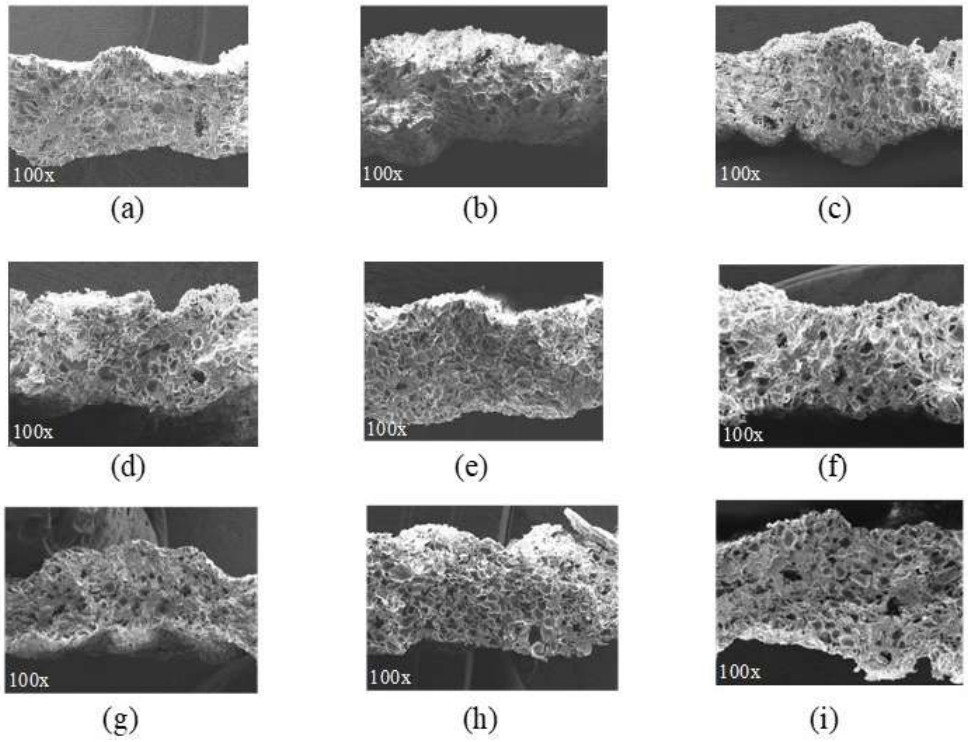


Figure 4. SEM images of the pineapple cores prepared by vacuum frying at 70 ºC (a, d, g), 75 ºC (b, e, h) or 80 ºC (c, f, i) for 50 min (a, b, c), 80 min (d, e, f) and 90 min (g, h, i) at a 100x magnification.

3.5. Sensorial evaluation

The results from the sensorial acceptance test of vacuum fried pineapple cores indicate a significant ($p \leq 0.05$) improvement in various sensorial attributes with different frying temperatures and times. At 70°C, variations in frying time between 50 to 90 minutes resulted in similar scores for appearance, color and flavor, ranging from 2.6 to 4.6. However, at 80°C for 90 minutes, attributes such as flavor, crispiness, and overall acceptability received the highest scores, exceeding 6 out of 7, with coefficients of 0.76, 0.93, and 0.79, respectively. This suggests that higher frying temperatures and longer frying times may be necessary to enhance consumer acceptability of vacuum fried pineapple cores. The vacuum fried pineapple cores produced at 80°C for 90 minutes exhibited a golden-yellow color, preferable flavor, and crispiness, as shown in Figure 1. The quality of the best recipe to produce vacuum fried pineapple cores is shown in Table 3.

Table 2. Hedonic scores of vacuum fried pineapple cores at various temperatures and time conditions.

Sample no.	Temperature (ºC)	Time (min)	Appearance	Color	Crispiness	Flavor	Overall Acceptance
1	70	50	4.60^{b}±0.83	4.07^{c} ±0.30	2.60^{d} ±0.55	3.60^{c} ±0.34	3.33^{d}±0.38
2		60	4.53^{b}±0.92	4.53^{b} ±0.42	2.67^{d} ±0.23	3.67^{c} ±0.35	3.60^{c} ±0.39
3		70	4.53^{b}±1.13	4.60^{b} ±0.63	2.67^{d} ±0.18	3.60^{c} ±0.49	3.60^{c} ±0.29
4		80	4.53^{b}±0.92	4.53^{b} ±0.74	2.80^{cd} ±0.22	4.20^{bc} ±0.56	3.87^{c}±0.35
5		90	4.47^{b}±1.06	4.60^{b} ±0.83	3.07^{cd} ±0.56	4.40^{bc} ±0.39	3.80^{c} ±0.48
6	75	50	4.80^{ab}±1.08	4.20^{b} ±0.41	3.27^{c} ±0.33	4.53^{b} ±0.44	3.93^{c} ±0.36
7		60	4.67^{b}±1.18	4.40^{b} ±0.74	3.40^{c}±0.40	4.47^{bc} ±0.83	4.27^{cd} ±0.59
8		70	4.87^{ab}±0.83	4.53^{b} ±0.64	3.47^{c} ±0.26	4.73^{b} ±0.56	4.13^{cb} ±0.44
9		80	4.87^{ab}±0.52	4.67^{b} ±0.52	4.20^{b} ±0.58	4.70^{b} ±0.28	4.07^{c} ±0.20
10		90	4.53^{b}±0.92	4.73^{b} ±0.46	4.20^{b} ±0.86	4.80^{b} ±0.42	4.20^{cb} ±0.48
11	80	50	4.87^{ab}±0.24	4.87^{b} ±0.35	4.00^{b} ±0.65	4.67^{b} ±1.29	4.20^{b} ±0.56
12		60	4.40^{b}±0.44	4.33^{ab} ±0.28	4.33^{b}±0.72	4.73^{b} ±0.70	4.40^{b} ±0.51
13		70	4.87^{ab}±0.34	4.80^{b}±0.41	5.20^{ab} ±0.77	4.80^{b} ±0.48	4.60^{b} ±0.44
14		80	5.07^{a}±0.36	4.87^{b} ±0.24	5.13^{ab} ±0.44	5.13^{ab} ±0.34	4.80^{b} ±0.41
15		90	5.13^{a}±0.22	5.67^{a}±0.49	6.07^{a} ±0.70	6.07^{a} ±0.53	6.20^{a} ±0.36

^{a,b,c,d} Mean values with different letters in the same column were significantly different ($p \leq 0.05$). Hedonic scores were reported in the 7-point scale; 1 = dislike extremely, 7 = like extremely.

In the vacuum fried pineapple core, neither the resistant starch nor the overall starch content could not be found. However, the pineapple exhibited a higher dietary fiber content compared to fresh pineapple. The best recipe sample (sample no.15) had a dietary fiber content of 21.31% (dry basis), higher than the 17.09% found in fresh pineapple. Dietary fiber is a plant polysaccharide that cannot be hydrolyzed and absorbed by human digestive enzymes. It has been reported that fiber intake can reduce the risk of cardiovascular disease, diabetes mellitus and cancer [26]. Additionally, when comparing the oil content of the best recipe sample to conventional French fries, it was found that the vacuum-fried pineapple core (sample no.15) contained 18% oil (Figure 2), while conventional French fries, the most popular fried food in the USA and many other countries, has a higher oil content of 43% [27]. This suggests that vacuum-fried pineapple cores offer a healthier alternative to traditional fried foods like French fries, with lower oil content and higher dietary fiber.

Table 3. Dietary fiber, total starch and resistant starch of fresh and the best recipe vacuum fried pineapple cores (sample no. 15).

Samples	Dietary Fiber (% db)	Total Starch (% db)	Resistant Starch (% db)
Fresh	17.09^{b} ±1.08	0	0
Vacuum fried (no. 15)	21.31^{a} ±1.34	0	0

^{a,b} Mean values with different letters in the same column were significantly different ($p \leq 0.05$).

4. Conclusion

The effect of vacuum conditions on the characteristics of pineapple cores were observed in this study. The variations in frying temperature and time influenced the moisture and oil contents of the pineapple cores. Additionally, the study found correlations between pore size, color, texture, SEM structures, expansion and crispiness. Products fried under pressure at 80°C for 90 minutes received the highest acceptance scores (over 6 out of 7) across all attributes, particularly overall acceptability. Noticeably, the vacuum-fried pineapple cores could serve as a potential product derived from industrial co-products. Furthermore, the study implies that these vacuum-fried cores could be positioned as a healthier alternative snack compared to traditional fried products like French fries, potentially appealing to health-conscious consumers.

Declaration of interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this report.

Acknowledgements

The authors gratefully acknowledge the funding support from the Research and Development Institute, Nakhon Pathom Rajabhat University (Grant number GB_62_8)

References

[1] Statistica, Leading countries in pineapple production worldwide in 2021,https://www.statista.com/statistics/298517/global-pineapple-production-by-leading-countries (access on 23 June 2023).

[2] D. I. Santos, C.F. Martins, R.A. Amaral, L. Brito, J.A. Saraiva, A.A. Vicente, M. Moldao Martins, Pineapple (Ananas comosus L.) By-products valorization : novel bio ingredients for functional foods, Molecules 26 (2021) 3216.

[3] M. Mohd Ali, N. Hashim, S. Abd Aziz, O. Lasekan, Pineapple (Ananas comosus): A comprehensive review of nutritional values, volatile compounds, health benefits, and potential food products, Food Research International 137 (2020) 109675.

[4] S. Ketnawa, P. Chaiwut, S. Rawdkuen, Pineapple wastes: a potential source for bromelain extraction, Food Bioproduct and Processing 90 (2012) 385-391.

[5] S. Banerjee, V. Ranganathan, A. Patti, A. Arora, Valorisation of pineapple wastes for food and therapeutic applications, Trends in Food Sciences and Technology 82 (2018) 60-70.

[6] A.K. Pandey, O.P. Chauhan, Process optimization for development of vacuum fried papaya (Carica papaya) chips using response surface methodology, Agricultural Research 8 (3) (2019) 364-373.

[7] A. H. Armad Tamizi, K. Niranjan, Post frying oil drainage from potato chips and French fries: a comparative study of atmospheric and vacuum drainage, Food bioprocess Technology 6 (2013) 489-497.

[8] A. Ren, S. Pan, W. Li, G. Chen, X. Duan, Effect of various pretreatments on quality attributes of vacuum -fried shitake mushroom chips, Journal of Food Quality (2018) 4510126.

[9] Food Infotech, An Overview on the Process & Effects of Vacuum Frying Technology on the Quality of Foods, https://www.foodinfotech.com/effects-of-vacuum- frying-technology-on-the-quality-of-foods-an-overview (access on 20 April 2024).

[10] R. Yamsaengsung, T. Ariyapuchai, P. Kilchanat, Effects of vacuum frying on structural changes of bananas, Journal of Food Engineering 106 (2011) 298-305.

[11] T.A. Esan, O.P. Sobukola, L.O. Sanni, H.A. Bakare, L. Monoz, Process optimization by response surface methodology and quality attributes of vacuum fried yellow fleshed sweet potato (Ipomoea batatas L.) chips, Food and Bioproducts Processing 95 (2015) 27-37.

[12] Y. Su, M. Zhang, W. Zhang, C. Liu, B. Adhikera, Ultrasonic microwave-assisted vacuum frying technique as a novel frying method for potato chips at low frying temperature, Food and Bioproducts Processing 108 (2018) 95-104.

[13] Y. Su, M. Zhang, W. Zhang, B. Adhikari, Z. Yang, Application of novel microwave assisted vacuum frying to reduce the oil uptake and improve the quality of potato chips, LWT 37 (2016) 490-497.

[14] P. Garcia-Segovi, A.M. Urbano-Ramos, S. Fiszman, J. Martinez-Monzo, Effects of processing conditions on the quality of vacuum fried cassava chio (Manihot Esculenta Crantz), LWT 69 (2016) 515-521.

[15] W. Wanakamol, P. Poonlarp, Effects of frying temperature, frying time and cycle on physicochemical properties of vacuum fried pineapple chips and shelf life prediction. International food research Journal 25 (6) (2018) 2681-2688.

[16] National science and technology development agency, BCG concept, https://www.bcg.in.th/eng/background (access on 7 November 2023).

[17] Association of Official Analytical Chemists, Official Methods of Analysis of

AOAC international, 16th ed, Washington DC: Association of Office Analytical, 2002.

[18] M. R. Mclellan, L. Lind, R.W. Kime, Hue angle determinations and statistical analysis for multiquadrant hunter L, a, b data, Journal of Food Quality 18 (1995) 235-240.

[19] A. Aumaporn, T. Kanitha, Quality of chilled and frozen starch gels as affected by starch type, highly concentrated sucrose and coconut milk, LWT - Food Science and Technology 147 (2021) 111534.

[20] American Association of Cereal Chemists, Approved Methods of the AACC, 8th ed., Minnesota: American Association of Cereal Chemists, 1990.

[21] A.K. Pandey, N. Ravi, O.P. Chauhan, Quality attributes of vacuum fried fruits and vegetables: a review, Journal of Food Measurement and Characterization 14 (2020) 1543-1556.

[22] V. Dueik, P. Robert, P. Bouchon, Vacuum frying reduces oil uptake and improves the quality parameters of carrot crisps, Food Chemistry 199 (2010) 1143–1149.

[23] S. Damodaran, K.L. Park, O.R. Fennema, Fennema' s food chemistry, 4th ed., Boca Raton: CRC,2008.

[24] E. Mardawati, D. M. Rahmah, N. Rachmadona, E. Saharina, T. Y. R. Pertiwi, S. A. Zahrad, W. Ramdhani, Y. Srikandace, D. Ratnaningrum, E. S. Endah, D. Andriani, K. S. Khoo, K. M. Pasaribu, R. Satoto, M. Karina, Pineapple core from the canning industrial waste for bacterial cellulose production by Komagataeibacter xylinus, Heliyon 9 (2023) e22010.

[25] F. Ayustaniangwarno, M. Dekker, V. Fogliano, R. Verkerk, Effect of vacuum frying on quality attributes of fruits, Food Engineering Review (2018) http:/doi.org/10/1007/s12393-018-9178-x.

[26] H.Yang, H. Lin, X. Liu, H. Liu, T. Chen, Z. Jin, Association Between Dietary Fiber Intake and Diabetic Nephropathy among Adult Diabetes Mellitus in the United States: A Cross-Sectional Study, Heliyon 10 (2024) e30036.

[27] X. Zhou, S. Zhang, Z. Tang, J. Tang, P.S. Takhar, Microwave frying and post-frying of French fries, Food Research International 159 (2022) 111663.

Interdisciplinary Research Review
Volume 19, Number 3, Pages 13–19

An Alternative Statistical Approach for the DOE with the Attribute Response

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Abstract

The design of experiment (DOE) with the result as an attribute is generally used. On the other hand, the current DOE method is quite complicated in that the user is supposed to transform the attribute result into the quantitative result, then turn it back again for a conclusion on the final parameter setting. The purpose of the research is to find out the efficient method that has the same result as the DOE. Finally, the research discovered that the logistic regression can be applied instead and get the final result of the parameters setting the same as the original DOE method. According to the users, they do not need to transform the attribute result into the quantitative result; this is the main idea: the users save a lot of time on calculations and can conclude the parameter setting by only interpreting the result from a factorial plot of logistic regression.

Keywords: Design of experiment, Attribute response, Logistic regression, Factorial plot

Article history: Received 10 January 2023, Revised 19 April 2024, Accepted 22 April 2024

The current industrial problem yields attribute data or qualitative data, such as pass/fail, good/bad, and so on, and is also related to the optimization of a parameter or process that has a qualitative result [1]. The design of the experiment needed to be set up to find out the correct parameter setting. Generally, the method that has been used is to transform the qualitative result into a quantitative result [2]. With this method, it takes more time and requires conversion back and forth before interpreting the result. The study aimed to apply other statistical methods that still maintain qualitative results and can be used to determine the factors that need to be set as well as the factors that are influenced by the interaction of factors. The statistical tool proposed is called "logistic regression". The Minitab data blog provided the data for the comparative study of the two methods. This is the original data that was supplied and used in the experiment design, along with the attribute result. The benefit of the research was finding a new method that can significantly reduce the step with the same answer as parameter setting with the DOE method. The comparison of a step reduction between the two methods is shown in Table 1.

Table 1. A comparison step between the existing method and the proposal method

The existing method	The proposal method
Key data in the Minitab sheet.	Key data in the Minitab sheet.
Transform the attribute data to probability.	Perform Logistic regression tool in Minitab software.
Calculate square root of probability and Arcsine later.	Interpret data and conclude for parameter setting.
Perform DOE tool in Minitab software.	
Interpret data and conclude for parameter setting.	

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2. Objective

To compare the decision-making by applying logistic regression instead of the DOE with the attribute response.

3. Literature review

3.1 Design of experiment (DOE)

The Design of Experiments (DOE) is a statistical technique that involves experiment planning and conducting, and findings analyzing and interpreting. It is a subfield of applied statistics used to conduct scientific investigations of a system, process, or product in which input variables (Xs) are changed to see how they affect the measured response variable (Y). In the past, DOE was a very effective strategy for enhancing the quality and dependability of products [3]. Today, numerous sectors employ DOE to help with decision-making for process improvement, new product development, and production procedures. It is employed in administration, marketing, hospitals, pharmaceutical industry, and engineering [4]. Regarding experiments with several elements, factorial designs are generally used when it is important to examine the combined impact of the factors on a response. The most significant of these particular instances has two levels for each of the k factors. These levels can be qualitative, such as the "high" and "low" levels of a factor, or they may also be quantitative, such as two values of temperature or time. A 2^k factorial design is a full replication of such a design, which is called $2 \times 2 \times 2 \times ... \times 2 = 2^k$ observations. An ANOVA (ANalysis Of VAriance) is used to verify the significant influence of each input factor and the interactions on the response factor. The setting of the factor is then considered on the factorial plot for each factor and its interaction. The ARCSINE method was used to transform the response data for the qualitative or attribute response. Users need to do a replicate response data and provide as a proportion result, then apply square root on the inverse sine (ARCSINE) to maintain the normality of the data [5]. Then they follows the ANOVA and draws a conclusion about the input factor setting from the factorial plot.

3.2 Logistic regression

Logistic regression is a technique for estimating the likelihood of an attribute outcome given a dependent variable. Binary logistic regression, often known as two outcomes such as pass or fail, yes or no, and so forth [6] is generally used, including in the industrial sector [7], the service sector [8], etc. The fundamental assumption of logistic regression is that it is identical to linear regression [9]. Residual is the difference between the expected and actual values of the response variable (error). Typically, it is assumed that the residual will have a normal distribution with a mean of 0 and constant variance. The residuals do not correlate with one another. The dependent variable and the residual do not correlate as well as the residual and the response variable. As a result of the outcome being determined by the likelihood that the event will occur, the response variable result will range from zero to one. A probability of one means the fascinating event has a 100% chance of happening, whereas a probability of zero means it is unlikely to happen. Assign probability of interested event is represented by *P(Y)*, and can be written as Equation (1):

$$P(Y) = \frac{e^{b_0+b_1X_i}}{1+ e^{b_0+b_1X_i}} \quad (1)$$

Then the non-interested event is represented by *Q(Y)*, and equation can be written as Equation (2):

$$Q(Y) = 1 - P(Y) \quad (2)$$

b_0 and b_1 are the estimated coefficients that are calculated from the data. X_i is the independent variable and e is a Natural Logarithm.

Logistic regression can be transformed to a logit equation to link the dependent variable to the independent variable. The equation form of logit link can be written as Equation (3).

$$Logit(P) = Log\left[\frac{P}{Q}\right] \quad (3)$$

An important number in the logistic regression is the odds ratio. By comparing *P* and *Q*, the odds ratio describes the number of times an event occurs. The odds ratio can be written as Equation (4).

$$Odds\ ratio = \frac{P_y}{Q_y} \quad (4)$$

One of the most important criteria to test for the fit of the logistic regression model is the likelihood value. The statistical software will calculate the likelihood value and transform it into a Chi-square distribution test with the degree of freedom of the independent variable. The main hypothesis of the Chi-square test is that "all coefficients of the logistic regression model are zero." While the null hypothesis was rejected, the conclusion is that "logistic regression has a model." The statistical software also provided the P-value for making a decision on accept or reject the null hypothesis based on the type I error percentage set up. Type I error is typically 5%.

3.3 A challenge of attribute response

The industrial sector and the service sector are all facing the result as an attribute. For example, the product cracks or does not crack, which is defined as an attribute result. However, almost everyone avoids using attributes as the result for fine-tuning any process setting. In this case, they define the length of the crack as represented by the number [10], even though sometimes they may fully break up. On the other hand, the end result as attributed may represent the real situation of what we need to monitor. Such as the component crack in the electronics component, as long as the crack is defined, there is an impact on the quality because there are so small [11]. Analyzing the data on the attributes is more complicated than using quantitative data [12]; thus, any attribute data always are converted to quantitative data for easier decision-making [13]. To maintain the end result as attributes and propose a method that the end result is the same rather than to convert fort and back the data, this research will explore any method that can be applied.

4. Methodology

The research is a comparison study between the DOE with attribute response and the logistic regression. The result of the parameter setting of the input factor is supposed to be the same, and the time saving is a key part of the study for the calculation and result interpretation.

The hypothesis of the research: Logistic regression can be used to set up the input factor with the same result as DOE's attribute response.

Based on the research hypothesis, the data and results from the Minitab were used for a comparison study [14] [15]. The data is 3 factors with 2 levels and 10 replications. The design is 2^3 = 8 Experiments with 10 replications mean 8 × 10 = 80 Runs.

Table 2. Raw data and results of experiment for a comparison study

Input Factor			Attribute Factor (OK/NOK)								
Factor 1	Factor 2	Factor 3	Output factor with 10 Replicates								
-1	-1	-1	NOK	OK	NOK	NOK	NOK	NOK	NOK	NOK	NOK
1	-1	-1	NOK	NOK	NOK	NOK	NOK	NOK	NOK	NOK	NOK
-1	1	-1	OK	NOK	OK	OK	OK	OK	OK	OK	OK
1	1	-1	NOK	OK	OK	OK	OK	NOK	NOK	NOK	NOK
-1	-1	1	NOK	OK	OK	NOK	NOK	OK	OK	OK	OK
1	-1	1	NOK	NOK	NOK	NOK	NOK	NOK	NOK	NOK	NOK
-1	1	1	OK	OK	OK	OK	OK	OK	OK	OK	OK
1	1	1	OK	OK	OK	OK	NOK	NOK	OK	OK	NOK

Table 3. Data transforming from Attribute to quantitative

Input Factor			Proportion (p)	Square root (p)	Arcsin (Sqrt (p))
Factor 1	Factor 2	Factor 3		Sqrt (p)	
-1	-1	-1	0.10	0.32	0.32
1	-1	-1	0.00	0.00	0.00
-1	1	-1	0.90	0.95	1.25
1	1	-1	0.40	0.63	0.68
-1	-1	1	0.70	0.84	0.99
1	-1	1	0.00	0.00	0.00
-1	1	1	1.00	1.00	1.57
1	1	1	0.60	0.77	0.89

The data transformation is an additional step for the DOE. In contrast, the logistic regression is not required. For logistic regression, the output "OK" is represented by 1 and the output "NOK" is represented by 0. The input factor put Low (L) and High (H) to represent -1 and 1. Then the logistic regression was performed and the factorial plot was provided in the result.

5. Result and discussion

5.1 DOE with attribute response and factorial plot result

Table 4. Summary result of DOE

Term	Coef	SE Coef	P-Value
Constant	0.71	0.06	0.000
Factor 1	-0.32	0.06	0.006
Factor 2	0.38	0.06	0.003
Factor 3	0.15	0.06	0.071

R-Sq = 94.84% and R-Sq adjust = 90.96%. There is no interaction between the factors.

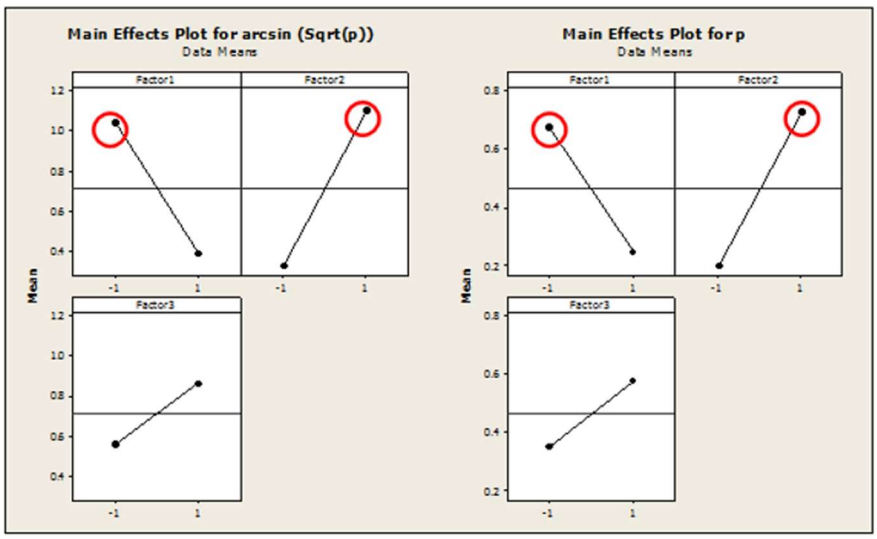

Figure 1. Factorial plot of DOE

Note. Optimizing Attribute Responses using Design of Experiments (DOE), Part 1. From https://blog.minitab.com/en/statistics-in-the-field/optimizing-attribute-responses-using-design-of-experiments-doe-part-1, by Jayakumar, M. Copyright 2022 by Minitab, LLC.

The conclusion based on the result analysis is to set up the maximum attribute response (a high "OK" rate). The analysis has shown that parameters for factors are set at the following levels:

Factor 1 setting at -1 (Low level).
Factor 2 setting at 1 (High level).
Factor 3 setting at 1 (High level, Factor 3 is less significant and might not have a high impact if changed to -1).

5.2 Logistic regression and factorial plot result (A proposal method)

Table 5. Summary result of DOE

Term	Coef	SE Coef	P-Value
Constant	0.83	0.59	0.000
Factor 1	3.82	1.11	0.001
Factor 2	-4.32	1.12	0.000
Factor 3	-1.83	0.69	0.008

R-Sq = 49.60% and R-Sq adjust = 46.88%. There is no interaction between the factors.

According to the P-value of each factor, it is lower than 0.05, which means all factors influence the response at a 95% confidence interval.

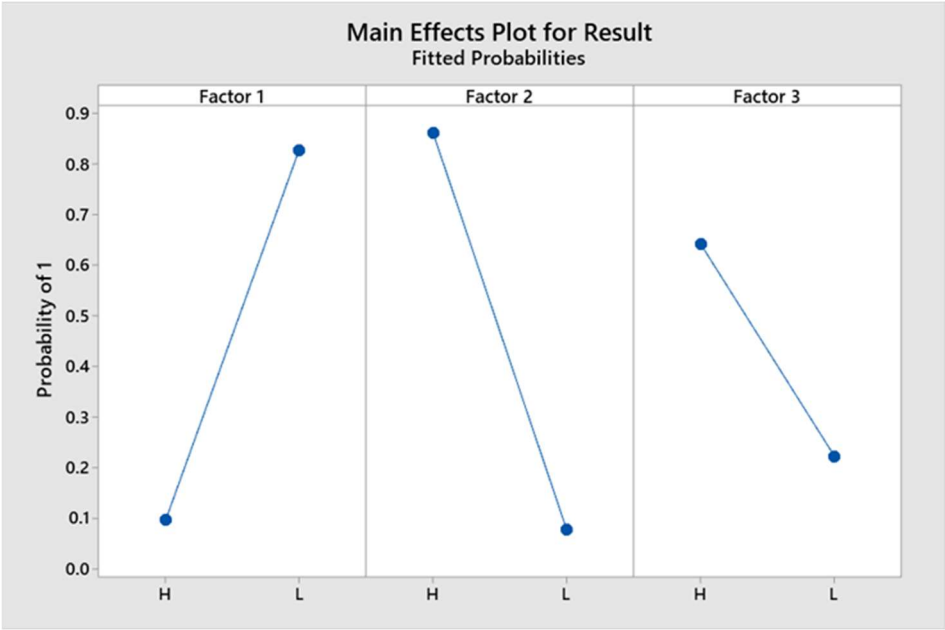

Figure 2. Factorial plot of Logistic regression

Note. Optimizing Attribute Responses using Design of Experiments (DOE), Part 2. From https://blog.minitab.com/en/statistics-in-the-field/optimizing-attribute-responses-using-design-of-experiments-doe-part-2, by Jayakumar, M. Copyright 2022 by Minitab, LLC.

The conclusion based on the result analysis is to set up the maximum attribute response (a high "OK" rate). The analysis has shown that

parameters for factors are set at the following levels:

Factor 1 setting at -1 (Low level).
Factor 2 setting at 1 (High level).
Factor 3 setting at 1 (High level).

The difference between DOE with attribute response and logistic regression is factor 3. At a 95% confidence level, the DOE indicates that factor 3 has no effect. In contrast, logistic regression suggests factor 3 has a significant impact at a 95% confidence interval. In terms of the different values of the R-Sq between the two methods, the R-Sq indicated how well dependent variables can explain the independent variable (or output of the system). The point of view for the practitioner is that they need to know how to set parameters specific to the "low" or "high" settings of each factor. Anyway, the conclusion of the setting for the system can be reached with the same result. This is suitable for the practitioner in the factory due to the calculation of the time they are saving. Regarding the logistic regression, users key in the result and run the statistical test, then the conclusion can be made. On the other hand, DOE needed to transform the data before running the statistical test. This step is taking more time than the logistic regression method. Finally, after setting the model as suggested, the result must be validated with at least 30 samples in the final step.

6. Conclusion

Referring to the research hypothesis, an alternate statistical method, called logistic regression, has the same result as the system setting up of the factor with the DOE's attribute response. This proposal is applicable to the 2^k factorial and produces a binary response. Therefore, the new method is beneficial in terms of time savings and step reduction. Moreover, this is a suitable method for the practitioner who needs to set up any system, machine, and so forth.

Acknowledgment

The researcher is grateful to the Industrial Engineering Department, Faculty of Engineering, Rajamangala University of Technology Rattanakosin for supporting the publication of this study.

References

[1] El-Haik, B., and Roy, D. M. (2005). Service design for six sigma: a roadmap for excellence. New Jersey: John Wiley & Sons.

[2] Anderson, V. L. and McLean, R. A. (1974). Design of experiments: a realistic approach (vol 5). CRC Press.

[3] Durakovic, B. (2017). Design of experiments application, concepts, examples: State of the art. Periodicals of Engineering and Natural Sciences, 5(3), 421-439. DOI: http://dx.doi.org/10.21533/pen.v5i3.145

[4] Paulo, F. and Santos, L. (2017). Design of experiments for microencapsulation applications: A review. Materials Science and Engineering: C, 77(August), 1327-1340.

[5] Mathews, P. G. (2004). Design of Experiments with MINITAB. Quality Press.

[6] Harrell F. E. (2015). Binary logistic regression (2nd ed.), In: Harrell FE (Ed.). Regression modeling strategies (pp. 219-274). Cham: Springer.

[7] Mahajan, R., Garg, S., Sharma, P. (2014). An illustration of logistic regression technique: A case of processed food sector. International Journal of Business Excellence, 7(5), 659-676.

[8] Su, Q., Shao, P. and Ye, Q. (2012). The analysis on the determinants of mobile VIP customer churn: A logistic regression approach. International Journal of Services Technology and Management, 18(1-2), 61 - 74.

[9] Montgomery D. C., Peck E. A. and Vining G. G. (2006). Introduction to Linear Regression Analysis (4th ed.). New Jersey: John Wiley & Sons.

[10] Aabid, A., Hrairi, M., and Ali, J. S. M. (2020). Optimization of composite patch repair for center-cracked rectangular plate using design of experiments method. Materials Today: Proceedings, 27, 1713-1719.

[11] Katemukda, N. (2021). Applying the logistic regression for the quality of microelectronics product. Journal of Applied Statistics and Information Technology, 6(2), 25-35.

[12] Pena, J. C., Nápoles, G., and Salgueiro, Y. (2022). Normalization method for quantitative and qualitative attributes in multiple attribute decision-making problems. Expert Systems with Applications, 198, 116821.

[13] Rao, R., and Lakshmi, J. (2021). R-method: A simple ranking method for multi-attribute decision-making in the industrial environment. Journal of Project Management, 6(4), 223-230.

[14] Optimizing Attribute Responses using Design of Experiments (DOE), Part 1, Available online in August 20, 2012, Available from: https://blog.minitab.com/en/statistics-in-the-field/optimizing-attribute-responses-using-design-of-experiments-doe-part-1

[15] Optimizing Attribute Responses using Design of Experiments (DOE), Part 2, Available online in August 23, 2012, Available from: https://blog.minitab.com/en/statistics-in-the-field/optimizing-attribute-responses-using-design-of-experiments-doe-part-2

Interdisciplinary Research Review
Volume 19, Number 3, Pages 20–30

The Development of Online Reading Lesson by Using Metacognitive Strategies of Thai Undergraduate Students

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Abstract

This study examined the development and determination of the efficiency of the online reading lesson by using metacognitive strategies and evaluated the achievements of the online reading lesson by using metacognitive strategies of Thai undergraduate students. Forty Thai undergraduate students who enrolled in English for Communication subject participated in the study for eight weeks. The research instruments employed six online reading lessons and exercises, an online reading lesson using metacognitive strategies tests, and a questionnaire on student's satisfaction towards the online lesson. Quantitative data were analyzed by mean, standard deviation (S.D.), and dependent t-test. The results revealed that the efficiency of the online reading lesson met the assigned criteria 75/75 and the achievements of learning indicated that the student's online reading abilities score obtained in the post-test after learning by online reading lesson were significantly higher than the pre-test at a .05 level of statistical significance. The students had high satisfaction towards online reading lessons because of their usefulness for their online reading.

Keywords: Online Reading, Metacognitive Reading Strategies, Online Reading Satisfaction

Article history: Received 30 April 2023, Revised 28 March 2024, Accepted 11 June 2024

1. Introduction

On a global scale, Thailand, like many other countries, has encountered the adverse impacts of the COVID-19 pandemic on various aspects of life such as the economy, society, and education. Consequently, it is crucial to address the issues of learning behavior and unequal access to knowledge. In this regard, leveraging technology can play a pivotal role in providing equitable opportunities for learners of all levels to acquire knowledge. Moreover, technology can be utilized to improve reading skills and promote healthy reading habits [1, 2, 3, 4, 5, 6]. The Thai education system needs to enhance the reading skills of Thai citizens to a level that enables them to acquire knowledge to effectively receive and comprehend the language. Reading is an important language ability in many aspects of life, including education and employment [7]. Employing reading strategies plays a crucial role in promoting reading comprehension and aids learners in accurately comprehending textual content [8].

Online learning materials are an essential tool for facilitating education and learning in contemporary times. Engaging in online reading and utilizing reading strategies, particularly metacognitive strategies, can enhance learning skills and foster autonomy in

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language acquisition. With the widespread use of technology in online learning across higher education institutions worldwide, research has shown that incorporating metacognitive strategies in online learning is crucial for achieving learner achievement [9, 10, 11].

Metacognitive strategies are cognitive processes that involve learners in their learning and self-learning processes. Several research studies have indicated that metacognitive strategies are significantly and positively associated with online learning performance, and are essential for achieving academic success [12, 13, 14, 15]. Students can enhance self-control through using metacognitive strategies in online learning [16, 17, 18]. As a result, online learning has the potential to improve the English language proficiency of all Nakhon Pathom Rajabhat University students.

The current research was conducted with the following intended objectives:

1) to develop and determine the efficiency of the online reading lesson by using metacognitive strategies of Nakhon Pathom Rajabhat University undergraduate students created by the researcher to meet the criteria of 75/75.

2) to compare learning achievements in online reading before and after learning online reading lessons by using metacognitive strategies of Nakhon Pathom Rajabhat University undergraduate students.

3) to study Nakhon Pathom Rajabhat University undergraduate students' satisfaction towards online reading lessons learning by using metacognitive strategies.

2. Literature Review

2.1 Concepts of Reading Theories

Reading involves connecting sounds with letters, and committing to memory various lexical items, phrasal combinations, and syntactical patterns, which employ the application of prior knowledge and understanding of the meaning [19, 20]. According to Breznitz [21], reading is an essential communication tool in society. It is an ability that allows the reader to interact with different forms of media. Reading therefore is essential in education. The viral in reading is reading comprehension level. Burmeister [22] classified the level of reading comprehension according to Bloom's Taxonomy as follows: memory, translation, interpretation, application, analysis, synthesis, and evaluation. Nunan and Dole [23] explained that reading comprehension relies on schema theory, emphasizing that understanding a text necessitates activating prior knowledge stored in memory. According to this theory, comprehension involves connecting new information with previously acquired knowledge. The reading process involves two main models: the bottom-up model, which involves processing the smallest components (e.g. letters) to larger units, and the top-down model, which involves drawing on prior experience and knowledge to understand meaning within a given context [24]. When the bottom-up and top-down approaches are integrated and used together, reading instruction can be more effective [25]. As a

result, the notion of an interactive reading process emerged, which involves generating and validating a hypothesis based on prior experiential knowledge. This process occurs through both top-down processing, which involves comprehending the larger context first and then breaking it down into smaller parts, and bottom-up processing, which involves analyzing individual components and then constructing a larger understanding [26]. In terms of metacognitive processes associated with intention, planning, and control strategies. Readers are capable of using reasoning and critical thinking to summarize the context [27].

2.2 Online Reading

Online reading differs from linear reading as it requires the reader to navigate through interconnected readings using hyperlinks. Rather than following a strictly linear progression, the reader must move between various passages related to the same subject [28]. The exploration of pedagogical approaches to facilitate the development of online reading skills. With effective search processes and metacognitive strategies, learners can enhance their experience and thinking abilities. Teachers should prioritize guiding students through the process of online information search. This will enable students to acquire and apply effective strategies for online reading comprehension [29, 30]. Following online instruction, educators must assess students' online reading skills. Ciampa [31] developed a method for measuring and evaluating online reading and reading strategy use. This includes the use of a reading motivation questionnaire and a list of reading activities. Furthermore, teachers can use a behavior observation form to monitor and record students' behavior while they engage in online reading activities.

2.3 Metacognitive Reading

Metacognition refers to the ability to have a practical understanding of one's thoughts. It involves knowledge of information processing skills, monitoring, and executing one's work. By examining their own thought and action strategies, individuals can use metacognitive strategies to control their thought processes and behavior. They can set goals and objectives for learning and assess their progress by being able to monitor and evaluate themselves. Hence, metacognition is the ability to regulate one's thoughts and actions. The approach to teaching English reading with an emphasis on metacognitive strategies involves the practice of different techniques in tasks that allow learners to understand the use of metacognitive strategies in planning, monitoring, problem-solving, and evaluating their learning process. This teaching method is supported by Cubukcu and Connel [32, 33] suggested that the use of metacognitive strategies in English teaching is crucial in helping learners become more aware of their metacognitive reading strategies. By applying these strategies, learners can adapt their reading habits and enhance their English reading skills. Phuvipadawat [34] evaluated the use of metacognitive reading strategies, which can be

measured and evaluated in two forms. The first form is testing, where the evaluation is performed through standardized tests. The second form is an authentic assessment, which includes observation, the use of tools, interviews, recordings, and reviewing student portfolios to assess their reading skills and strategies.

2.4 Related Literature

Sitiprakan et al. [35] conducted a study to investigate the effectiveness of online lessons on students' advanced reading achievement. The results indicated that learners who used online lessons showed greater improvement in their English learning achievements. Furthermore, the study found that online lessons were beneficial in enhancing learners' knowledge of English reading. The survey conducted also showed a positive impact of online learning, as students expressed high levels of satisfaction. Cigdem and Tirkes [36] conducted research on various analyses and benefits of LMS and Moodle. They found that Moodle and LMS are remarkable open-source software, which aim to improve the quality of education and include necessary tools for an e-learning system. Moodle and LMS provide multiple features that enhance the pedagogical quality and offer the necessary tools required for an e-learning system. LMS plays a significant role in the virtual learning environment (VLE) or learning platform. According to Hall [37], LMS is software that automates the management of training events. LMS manages the login of registered users, manages course catalogs, stores data from learners, and generates reports for management purposes. Liu and Feng [38] studied the correlation between metacognitive and online learning strategies and academic achievement. Their findings revealed that using these strategies helped students in the test-scoring group to achieve higher overall outcomes.

3. Methodology

3.1 Participants

The participants were a class that had forty students who enrolled in 1500134 English for Communication in the second-semester academic year 2021 and are taught by the researcher. The students registered for this course for the first time. They are non-English majors who were studying in their second year at Language Institute, Nakhon Pathom Rajabhat University. The class was selected by purposive sampling.

3.2 Research Instruments

The instruments used in the study were a lesson plan for a course English for Communication 1500134. It was included learning objectives and course descriptions for English for Communication. In addition, the researcher designed the online material which is composed of six chapters that focus on online reading content using metacognitive strategies using a Learning Management System (LMS) provided by Nakhon Pathom Rajabhat University. Moreover, a pre-posttest in metacognitive online reading was employed in this study, which consisted of a multiple-choice

test with 40 items. The test aimed to measure reading comprehension using metacognitive strategies, which include: 1) distinguishing between the main idea and supporting details, 2) identifying supporting details, 3) guessing unknown words, 4) summarizing main ideas, 5) interpreting the text, and 6) evaluating the text. Furthermore, the Student Satisfaction Questionnaire was used to affirm the results of satisfaction towards metacognitive online reading.

3.3 Research Procedures

This research aims to investigate the methodology used in the study. This research conducts quantitative methods into the study. The data collection comprises the research design, construction of the research instrument, and satisfaction questionnaire towards metacognitive online reading strategies. The main objective of the study on the development of online reading lessons by using metacognitive strategies of Thai undergraduate students at Nakhon Pathom Rajabhat University. The procedures are as follows.

1) The English for Communication course 1500134 comprises six units, emphasizing online reading and metacognitive strategies. It includes learning objectives and course descriptions. Online lessons, delivered in various formats, were developed following content analysis using selected websites. They were integrated into the university's Learning Management System (LMS) for course management, student data handling, evaluation, and communication. The researcher analyzed online content, created test specifications, and developed a test to assess online reading and metacognitive skills. Both the online lessons and the test underwent expert review and were trialed with experimental groups.

2) The researcher provided a comprehensive explanation of the research particulars to the students. The students were given consent forms and informed of their right to withdraw from the study at any point, without facing any detrimental consequences. Subsequently, the researcher executed the following stages.

3) In the first phase, the students took an online reading proficiency test employing metacognitive strategies via Google Forms before starting the online lessons. The test consisted of 40 questions and lasted for one hour. This process was during the first week of the study. Throughout this process, students were prompted to utilize metacognitive techniques.

4) In the second phase, the researcher developed the online reading lessons, including PowerPoint creation, videos, teaching materials, and exercises. These materials were downloaded from the YouTube platform and uploaded to the LMS. The course comprised six chapters, and students took three hours per week, totaling 18 hours. The study took six weeks to cover all six chapters. Then, students were required to spend an hour every weekday after class finishing the task on the LMS platform. In addition, students were required to engage in post-learning exercises after finishing each chapter, comprising ten items per chapter,

and taking 30 minutes to complete. The students spent total time for post-learning exercises across all six chapters was 180 minutes. The LMS enhanced delivery through content management, interactive videos with metacognitive prompts, quizzes for self-assessment, discussion forums for reflective activities, progress tracking, announcements, resource links, and assignment submission features.

5) In the third stage, after the online lessons, students undertook an online reading ability test using metacognitive strategies through Google Forms. This test contained 40 questions and lasted for one hour. It took place during the seventh week of the study. Students had to use their after-school time to complete it.

6) In the final stage, following the completion of the online reading lessons using metacognitive strategies, students were asked to complete a Student Satisfaction Questionnaire via Google Form. This questionnaire consisted of ten questions and was administered after the seventh week of the study.

3.4 Data Analysis

The data analysis of the study was based on the SPSS which was used to analyze data obtained from pre-posttest in metacognitive online reading by using t-test for dependent samples to get statistical method. Moreover, data was obtained by using mean ($\overline{X}$), standard deviation (S.D.) and process ($E_{1)}$, and product ($E_{2)}$ for the online reading lessons' content validity and reliability, and satisfaction questionnaire.

4. Results and Discussion

The online reading lessons met the efficiency criteria of 75/75, indicating their efficiency in enhancing students' reading skills. Furthermore, the comparison of pre-test and post-test scores revealed a significant improvement in students' reading abilities and skills after participating in the online reading lessons. The post-test scores were significantly higher than the pre-test scores, indicating the positive impact of the online reading lessons using metacognitive strategies. Additionally, students reported high satisfaction with the online reading lessons, particularly appreciating their format and content, which were rated as highly useful and easy to use. The findings indicate that metacognitive strategies effectively enhance reading comprehension. Moreover, the improvement in post-test scores aligns with previous research [12-14], demonstrating the positive impact of these strategies on academic achievement. The high satisfaction levels further validate the efficiency of the online lessons, corroborating studies by Sitiprakan et al. [35] and Cigdem and Tirkes [36].

In summary, nationally and internationally research supported the use of online language lessons, online reading, and the use of metacognitive reading strategies. Therefore, the researcher developed online reading lessons using metacognitive reading strategies to help students develop English

language skills and abilities. In addition, online reading lessons using metacognitive reading strategies influence vocabulary learning enrichment, participatory learning encouragement, teacher-student interaction stimulation, support learning, enable assessment and tracking of activities, and provide convenient and timely access to instructional materials. This approach is very satisfying for students.

4.1 Results of developing and determining the efficiency of the online reading lesson by using metacognitive strategies

Brahmawong [39] conducted a three-stage tryout, presenting the findings on the efficiency of the draft online reading lessons as follows:

In Individual Testing (1:1), 3 students who had similar characteristics to the samples were employed in this stage. The following is the table of finding on the efficiency of the online reading lessons draft in the individual testing stage.

Table 1: Efficiency of the Online Reading Lessons Draft in Individual Testing (1:1)

Efficiency	Students (n)	Total scores	$\bar{X}$	S.D.	Efficiency Value
Process (E_1)	3	60	45.30	6.65	75.50
Product (E_2)	3	40	30.30	9.29	75.75

In the first stage of the tryout, the findings on efficiency (E_1 / E_2) of the online reading lesson draft were 75.50/75.75 which meant the draft met the set criteria at 75/75.

In Group Testing (1:10), 10 students who had similar characteristics to the samples were employed in this stage. The following is the table of findings on the efficiency of the online reading lessons draft in the Group Testing stage.

Table 2: Efficiency of the Online Reading Lessons Draft in Group Testing (1:10)

Efficiency	Students (n)	Total scores	$\bar{X}$	S.D.	Efficiency Value
Process (E_1)	3	60	45.10	3.14	75.16
Product (E_2)	3	40	30.10	6.60	75.25

In the second stage of the tryout, the finding on efficiency (E_1 / E_2) of the online reading lessons draft was 75.16/75.25 which meant that the draft still met the set criteria at 75/75.

In Field Testing (1:100), 40 students who had similar characteristics to the samples were employed in this stage. The following is the table of finding on the efficiency of the draft in the Field Testing stage.

Table 3: Efficiency of the Online Reading Lessons Draft in Field Testing (1:100)

Efficiency	**Students (n)**	**Total scores**	**$\bar{X}$**	**S.D.**	**Efficiency Value**
Process (E_1)	3	60	45.35	3.23	75.58
Product (E_2)	3	40	30.70	3.17	76.75

In the final stage of the tryout, the finding on efficiency (E_1 / E_2) of the online reading lessons draft was 75.58/76.75 which meant the draft met the set of criteria at 75/75. These results suggest that the online reading lessons possessed the quality necessary for further dissemination.

4.2 Results of comparing learning achievements of online reading before and after learning online reading lessons by using metacognitive strategies

In this part, the results gained from both pre- and post-test were compared to see the achievement of students' online reading before and after employing online reading lessons by using metacognitive strategies.

Metacognitive Online Reading Test	**Students (N)**	**$\bar{X}$**	**S.D.**	**t-value**	**p**
Pre-test	40	22.38	4.60	18.13	0.00
Post-test		30.70	3.17		

* Significant at the 0.05 level ($p < 0.05$)

The table indicates the mean scores of both pre- and post-tests showing the students' online reading. Before the students studied by using the online reading lessons using metacognitive strategies, they had taken the pre-test and the mean score was 22.38 ($\bar{X}$), 4.60 (SD). However, they had to take the post-test after the online reading lessons by using metacognitive strategies were employed. The result of the post-test that the mean score was 30.70 ($\bar{X}$), 3.17 (SD), was higher than the pre-test. However, the scores between the pre and post-test were significantly different at 0.05 level ($t = 18.13$, $P = 0.00$). Therefore, the results of paired t-test indicated that Thai undergraduates' overall online reading after implementing online

reading lessons was higher. It can be concluded that Thai undergraduates' overall achievement towards online reading lessons by using metacognitive strategies was enhanced after the implementation.

4.3 Results of affirming students' satisfaction towards online reading lessons by using metacognitive strategies.

Apart from the overall satisfaction towards online reading lessons, three aspects of students' satisfaction were also administered and analyzed quantitively by using mean and standard deviation.

Satisfaction aspects	$\bar{X}$	S.D.	Satisfaction	Rank
Student	4.14	0.06	High	3
Content	4.15	0.01	High	2
Format	4.17	0.02	High	1
Total	4.15	0.04	High	

The table presents the mean scores and standard deviations for students' satisfaction with online reading lessons utilizing metacognitive strategies, evaluated on a 5-point Likert scale. From this questionnaire, the derived mean score and standard deviation were 4.15 ($\bar{X}$) and 0.04 (SD), respectively. Notably, the ranking based on mean scores highlights that the format of the online reading lessons was the highest at 4.17 ($\bar{X}$), followed by content satisfaction at 4.15 ($\bar{X}$), and student satisfaction at 4.14 ($\bar{X}$). This indicates that students were most satisfied with the format, followed closely by content and student satisfaction. The positive feedback reflects the students' appreciation and endorsement of the efficiency of the online reading lessons integrated with metacognitive strategies.

5. Conclusion

This study has several key points that relate to its objectives. The purpose of the research was to determine the effectiveness of online reading lessons by using metacognitive strategies among undergraduate students at Nakhon Pathom Rajabhat University. The researcher created online reading lessons for the English for Communication course 1500134, which consisted of six chapters. The efficiency of the material (E_1/E_2) was evaluated based on the practice and post-test scores of all the participants, which were 75.58% and 76.75%, respectively (E_1/E_2 = 75.58 /76.75). The researcher systematically designed and developed online lessons that met quality standards and were evaluated by experts. The lessons were evaluated based on their content and met the criteria set forth at 75/75.

The study analyzed the learning achievement of undergraduate students at Nakhon Pathom Rajabhat University who used online reading lessons by using metacognitive strategies. The results showed that the student's learning achievement was higher after using the online reading lesson designed by the researcher. The online reading lessons were designed to be easily understood and included video lessons, additional sources of knowledge, and interesting modern titles, sizes, colors, and fonts. The learners could interact with the lessons, and students could review the lessons anytime, anywhere. The study also found that the students had a high level of satisfaction with the format of the online reading lessons. Future studies should explore the long-term impact of these strategies and investigate their applicability in different educational contexts. Furthermore, the limitation of this study's sample size, confined to one university,

potentially impacts the generalizability of the findings. Thus, future research should encompass larger and more diverse samples. Additionally, recommendations for future studies should include investigating the influence of metacognitive strategies on other language skills and exploring their integration into various educational technologies.

References

[1] Mayer, R. E. Multimedia Learning: Are We Asking the Right Questions? Educational Psychologist. 32(1): 1-19, 1997, Available from: http://www.uky.edu/~gmswan3/544/mayer_1997.pdf.

[2] Kymes, A. D. Investigation and Analysis of Online Reading Strategies. Dissertation (2007).

[3] Coiro, J. Dobler., E. Exploring the online comprehension strategies used by sixth-grade skilled readers to search for and locate information on the Internet. Reading Research Quarterly, (2007) 214-257.

[4] Biancarosa, G., & Griffiths, G. G. Technology tools to support reading in the digital age. Future of Children, 22(2) (2012) 139-160.

[5] McMahon, M.; Oliver, R. Teaching Metacognitive Regulation of Reading Comprehension in an On-line Environment. Edith Cowan University Research Online. ECU Publications Pre. 2011 (2003).

[6] Leu, M., S. E. Hanser, and S. T. Knick. The human footprint in the west: A large-scale analysis of anthropogenic impacts. Ecological Applications 18(5) (2008) 1119-1139.

[7] Grigg, N. & Mann, R. Promoting excellence: An international study into creating awareness of business excellency models". The TQM Journal, 20(3) (2008). 233-248.

[8] Kasemsap, B., & Lee, H. Y. H. L2 reading in Thailand: Vocational college students' application of reading strategies to their reading of English texts. The Reading Matrix Journal, 15(2) (2015) 101-117.

[9] Deschacht, N., & Goeman, K. The effect of blended learning on course persistence and performance of adult learners: A difference-in-differences analysis. Computers & Education, 87, (2015) 83–89.

[10] Spanjers, I., Könings, K. D., Leppink, J., Verstegen, D., Jong, N., Czabanowska, K., & Merriënboer, J. The promised land of blended learning: Quizzes as a moderator. Educational Research (2015) 59–74.

[11] Abdul Wahab, N., Othman, J., & Warris, S. N. Blended learning in higher education: An overview. e-Academia Journal UiTMT, 5(2) (2016) 115–122.

[12] Dumford, A. D., & Miller, A. L. Online learning in higher education: Exploring advantages and disadvantages for engagement. Journal of Computing in Higher Education, 30(3) (2018) 452–465,

[13] Broadbent, J., & Poon, W. L. L. Self-regulated learning strategies & academic achievement in online higher education learning environments: An Internet and Higher Education, 27 (2015) 1–13.

[14] Goradia, T., & Bugarcic, A. A social cognitive view of self-regulated learning within online environment. Advances in Integrative Medicine., 4(1) (2017) 5–6.

[15] Cho, M. H., & Heron, M. L. Self-regulated learning: The role of motivation, emotion, and use of learning strategies in students' learning experiences in a self-paced online mathematics course. Distance Education, 36(1) (2015) 80–99, Available from: https://doi.org/10.1080/01587919.2015.1019963.

[16] Anthonysamy, L., Koo, A-C., Hew, S.-H. Self-regulated learning strategies and non-academic outcomes in higher education blended learning environments: A one-decade review. Education and Information Technologies, 1–28 (2020) 10.1007/s10639-020-10134-2.

[17] Lilian A, Ah-Choo K, Soon-Hin H. Investigating self-regulated learning strategies

for digital learning relevancy. Malaysian Journal of Learning and Instruction. (2021) 18(1):29–64.

[18] Farahian, M., & Farshid, M. A reader response approach to reading: Does it have an effect on metacognitive reading strategies? Modern Journal of LanguageTeaching Methods, 4(1) (2014) 371–383.

[19] Leu, D. J., Kinzer, C. K. Effective reading instruction: K-8 (2nd ed.) Columbus, OH: Merrill, 1991.

[20] Perfetti, C. A., Landi, N., & Oakhill, J. The acquisition of reading comprehension skill. In M. J. Snowling, & C. Hulme (Eds.), The science of reading: A handbook 227–247. Oxford: Blackwell, 2005.

[21] Breznitz Zvia. Fluency in Reading Synchronization of Processes. Lawrence Erlbaum Associates, Publishers Mahwah, New Jersey. London, 2006.

[22] Burmeister, Low E. Improving Speed of Comprehension in Reading Strategies of Secondary School Teaching. Massachusetts: Addison Wesley, 1974.

[23] Nunan, D. Important tasks of English education: Asia-wide and beyond. Asian EFL Journal, (2005) 7(3).

[24] Dole, J. A. Duffy, G. G., Roehler, L. R., and Pearson, D. D. Moving from the old to the new: research on reading comprehension instruction. Review of Educational Research 61, 1991.

[25] Stanovich, K.E. Toward an interactive-compensatory model of individual differences in the development of reading fluency. Reading Research Quarterly, (1980) 16, 32-71.

[26] Barchers, S. Teaching Reading from Process to Practice. USA: R.R Donnelly & Sonns, 1998.

[27] Block, E. L. See how they Read: Comprehension Monitoring of L1 and L2 Readers. TESOL Quarterly 26 (1992) 2:319-43

[28] Peplow, D., Carter, R. Stylistics and real readers. In: Burke, M (ed.) The Routledge Handbook of Stylistics. London: Routledge, (2014) 440–454.

[29] Nachmias, R. G., A. Needle in a hyperstack: Searching for information on the World Wide Web. Journal of Research on Technology in Education, 34 (2002) 475-486.

[30] Eagleton, M., Guinee, K., & Langlais, K. Teaching Internet literacy strategies: The hero inquiry project. Voices from the Middle, 10(3) (2003) 28-35.

[31] Ciampa, K. Reading in the Digital Age: Using Electronic Books as a Teaching Tool for Beginning Readers. Canadian Journal of Learning and Technology, (2012) 38(2).

[32] Cubukcu, F. Enhancing vocabulary development and reading comprehension through metacognitive strategies. Issues in Educational Research,18(1) (2008)1-11.

[33] Connell, D. A Phenomenological Study: Explicit Metacognition Instruction in the AVID Program (Doctoral dissertation). The Faculty of the College of Graduate Studies. Lamar University, 2015.

[34] Phongkan Puwiphadawat. Teaching techniques for English Reading at the Secondary Level. Teaching materials for the course 058488. Secondary Education Department, Faculty of Education Chiang Mai University, 1997. (In Thai).

[35] Sitipragan K,, Chantarangul V., and Thongsai., P. Student's Achievement on Advanced Reading Through Online Lessons. (Research Report). Rajamangala University of Technology Srivijaya Nakhon Si Thammarat Campus, 2019. (In Thai).

[36] Cigdem. C., & Tirkes, G. Open-source learning management systems in e-learning and Moodle. In IEEE EDUCON 2010 Conference (2010) 593-600.

[37] Hall, B. New Technology Definitions, (2003), Available from: http/brandonhall.com/public/glossary.

[38] Liu, Y., & Feng, H. An empirical study on the relationship between metacognitive strategies and online-learning behavior & test achievements. Journal of Language Teaching and Research, 2(1) (2011) 183-187.

[39] Brahmawong, C. Developmental testing of media and instructional package. Silpakorn Education Research Journal. 5(1) (2013) 1 -20. (In Thai).

Interdisciplinary Research Review
Volume 19, Number 3, Pages 31–40

The development model of internal supervision management according to standards of the early childhood education schools under the Office of the Basic Education Commission

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Abstract

The objectives of this study were 1) to study the relevant documents and confirm the elements of internal supervision management according to standards of the early childhood education schools under the Office of the Basic Education Commission (OBEC), 2) to investigate the present situations, management problems, and feasible guidelines for internal supervision management according to standards of the early childhood education schools under the OBEC, and 3) to develop and verify of internal supervision management according to standards of the early childhood education schools under the OBEC. This research used a mixed-methods approach. The key informants consisted of experts, school administrators, supervisors, academic heads, and early childhood teachers, for a total of 49 informants. The instruments used for collecting data were a component synthesis table, an in-depth interview, a verification form for a draft model and a manual, and an evaluation form for a model and a manual. The statistics used for analysis were frequency, percentage, and content analysis. The research results were as follows: 1. The elements of internal supervision management according to standards of the early childhood education schools under the OBEC after confirmation comprised four components: 1.1) planning, 1.2) organizing, 1.3) leading, and 1.4) controlling. 2. The current situations, management problems, and feasible guidelines for internal supervision management according to standards of the early childhood education schools under the OBEC also comprised of four elements: 1.1) planning, 1.2) organizing, 1.3) leading, and 1.4) controlling. 3. A model of internal supervision management according to standards of the early childhood education schools under the OBEC comprised of five components: 1) principles; 2) objectives, 3) operational procedures, 4) evaluation, and 5) conditions for achievement. The accuracy and suitability of the internal supervision management were both at the highest level.

Keywords: Internal Supervision Management, Standards of Early Childhood Education, Office of the Basic Education Commission (OBEC)

Article history: Received 29 September 2023, Revised 19 June 2024, Accepted 21 June 2024

1. Introduction

Thailand's 20–Year National Strategy (2017-2036) [10] encourages life cycle development with a focus on growing individuals at all stages of development in accordance with their age groups. Therefore, the national strategy for enhancing human capital emphasized the importance of quality family planning, parental readiness, breastfeeding promotion, accurate infant nutrition guidance, and investments in early childhood development facilities during the pregnancy and early childhood stages.

At the same time, the Bureau of Academic and Educational Standards, Office of the Basic Education Commission Ministry of Education [1] determined that the Early Childhood Education Curriculum

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Manual had been created with the aim of offering guidance on structuring meaningful experiences for young children. It achieved this by aligning these experiences with the principles of developmental psychology and brain function that were appropriate for each child's age, maturity, and developmental stage. This approach ensures that every child has the opportunity to reach their maximum potential. The manual emphasizes the importance of tailoring experiences to match children's unique learning styles. It encourages children to engage their five senses, movement, exploration, play, observation, investigation, experimentation, and independentproblem-solving. Furthermore, the manual advocates for an integrated approach to learning, where activities, skills, and educational content are woven together seamlessly. It promotes experiences that empower children to take initiative, plan, make decisions, take action, and present their ideas, with support from instructors or experienced facilitators. The manual also stresses the importance of collaborative learning by facilitating interactions between children and between children and adults in an environment that fosters a warm, joyful atmosphere conducive to learning. This approach encourages children to engage in cooperative activities in various ways.

In line with the National Educational Standards, B.E. 2561 (2018) [8] stated that the desired educational outcomes accumulate characteristics of early childhood education to have well-rounded development and balance; attend to learn, and control oneself to do proper things.

Moreover, the Guidelines for Quality Assessment by Educational Standards for Early Childhood Education according to the Office of the Basic Education Commission [2] consisted of the quality of learners, administrative and management process, and child-centered experience management.

Meanwhile, UNICEF Regional Office for South Asia [14] must enhance the efficiency of monitoring and supportive supervision efforts. The monitoring system in childcare centers plays a crucial role in ensuring service quality and could be expanded to cover the preschool education sector. However, a major obstacle to its effectiveness, as indicated in the review materials, is the limited capacity of both institutions and individuals, particularly the professional understanding at the provincial level, to conduct effective monitoring and offer mentorship support. Therefore, it is essential to focus on capacity building for officials, especially at decentralized implementation levels, as it is integral to ensuring and maintaining service quality.

Likewise, Kanyayon [4] revealed that the framework for enhancing educational quality via the school's internal supervision process comprises several stages. These stages encompass initial preparation, identifying responsible personnel and managing the information system, defining the roles and responsibilities for both supervisors and those under supervision, creating participatory internal supervision plans, executing the supervision process and implementing the plan, conducting the actual supervision, overseeing the process, conducting follow-up activities, employing various assessment tools for monitoring, evaluating the effectiveness of supervision, wrapping up the supervision efforts, proposing recommendations and solutions, and documenting the supervision in a report.

'Internal supervision management' in Thailand refers to the processes and systems used by organizations and institutions to oversee their internal operations. This includes activities like monitoring employees, coordinating projects, ensuring quality, and managing the organization's governance. It involves setting standards and procedures for internal supervision and promoting collaboration between supervisors and

those being supervised. This collaboration includes tasks such as analyzing the situation, planning supervision, creating tools, conducting supervision, and evaluating its results.

However, as a teacher of early childhood in charge as a deputy administrator under the OBEC, realize the importance of early childhood education, especially in the first five years of life, which is considered the best time for learning. Understanding child development has many positive effects on teachers. One good result is that it helps teachers better understand the learning process of children, also plan courses. Teaching and learning can be more appropriate for each child according to their potential. As for supervision, it is considered the heart of developing the quality of learning management. Another good result is that teachers receive good advice. Moreover, they develop oneself as advised by the supervisor and have worked together to develop the process to proceed correctly. It will help increase teachers' confidence in learning management. It helps teachers understand children's learning processes better; that is, learners receive quality processes, learn with curiosity, and are more willing and ready to learn. Therefore, the researcher, as educational personnel directly involved in early childhood education, sees that internal supervision affects the quality of early childhood children, and wants to develop internal supervision management according to the quality standards of early childhood education in educational institutions under the OBEC. This is for the benefit of developing early childhood education in the future.

2. Research Questions

2.1 What are the synthesized results of the relevant documents and confirm the elements of internal supervision management according to standards of the early childhood education schools under the OBEC?

2.2 What are the present situations, management problems, and feasible guidelines of internal supervision management according to the standards of the early childhood education schools under the OBEC?

2.3 What are the components of a development model of internal supervision management according to the standards of the early childhood education schools under the OBEC?

3. Research Objectives

3.1 To synthesize the relevant documents and confirm the elements of internal supervision management according to the standards of the early childhood education schools under the OBEC.

3.2 To investigate the present situations, management problems, and feasible guidelines of internal supervision management according to the standards of the early childhood education schools under the OBEC.

3.3 To develop a model of internal supervision management according to the standards of the early childhood education schools under the OBEC.

4. Materials and Methods

The research procedures were operated in three phases, as follows:

Phase 1: The synthesizing of the relevant documents and confirming the elements of internal supervision management according to standards of the early childhood education schools under the OBEC. The statical used was frequency.

Phase 2: The investigation of the present situations, management problems, and feasible guidelines of internal supervision management according to standards of the early childhood education schools under the OBEC. Key informants consisted of early childhood teachers with more than one-year experiences and academic teachers in charge of early childhood education in eight provincial schools under the OBEC in the upper north region, for a total of 16

respondents. An instrument used was an in-depth interview form using the synthesis core elements from phase 1 to be inquiry issues, consisting of four elements 1) planning, 2. organizing, 3) leading, and 4) controlling. The content analysis was used to classify by issues.

Phase 3: The development of a model of internal supervision management according to the standards of the early childhood education schools under the OBEC was classified into two steps:

Step 3.1: A model of internal supervision management according to the standards of the early childhood education schools under the OBEC was drafted by the research team based on the synthesis results from Phase 1 and the investigation results from Phase 2 to classify significant issues comprising of five components: 1) principles; 2) objectives, 3) operational procedures, 4) evaluation, and 5) conditions for achievement.

The research framework is explained in Figure 1.

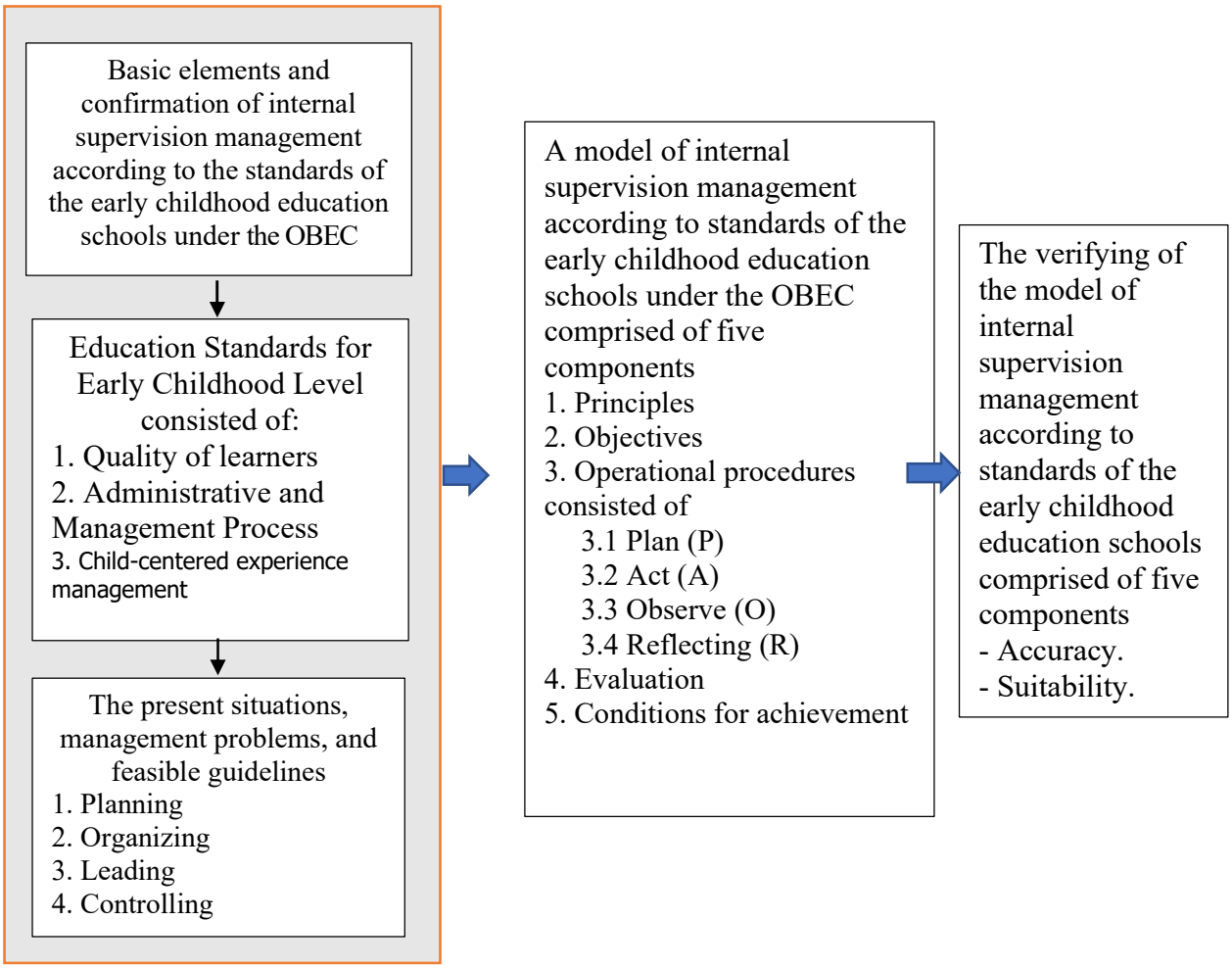

Figure 1: Research framework

Step 3.2: The verification of the accuracy and suitability of a model of internal supervision management according to the standards of the early childhood education schools under the OBEC was conducted by key informants comprised fifteen experts selected by purposive sampling. They were lecturers, supervisors,

school administrators, and early childhood teachers. The instruments used were a draft model and a verification form.

The results of the verification were analyzed with frequency and percentage. The research framework is explained in Figure 1.

5. Results and Discussion

The research procedures were divided into three phases as follows:

Phase 1: After the confirmation, the results of synthesis of the elements of internal supervision management according to the standards of the early childhood education schools under the OBEC consisted of four elements: 1) planning, 2. organizing, 3) leading, and 4) controlling. [6]

Phase 2: The results of investigating the present situations, management problems, and feasible guidelines of internal supervision management according to the standards of the early childhood education schools under the OBEC are shown in Table 2.

Table 2: Results of investigating the current situations, management problems, and feasible guidelines

The present situations	The management problems	The feasible guidelines
Planning		
- Ensure that planning is the core principle of OBEC standards for Early Childhood Education. - These plans are not designed in line with National Education Standards 2018. - The planning process does not ensure alignment with the OBEC standards for Early Childhood Education. - The digital platforms or applications are not used for data collection and analysis.	- Lack of setting clear and specific objectives for their internal supervision processes. - Lack of challenge to measure the effectiveness of supervision activities. - Leading to inconsistencies in the quality of supervision. - Inadequate use of data collected during supervision for planning purposes. - Leading to confusion among supervisors and teachers about the intended outcomes. - Limited financial resources to develop comprehensive supervision plans.	- Review and update plans regularly to reflect changes in standards. - Define clear and measurable objectives for internal supervision management. - Planning on data collected through assessments, observations, and evaluations for improvement. - Maintain all planning activities, including supervision plans, goals, timelines, and responsibilities. - Plan supervision activities that focus on academic achievement. - Involve parents and local community members in the supervision management to support early childhood education.
Organizing		
- Ensure that team members have the required qualifications and expertise. - Schools carefully organize their supervision teams - Ensure that schools allocate resources to training supervisors. - Early childhood education institutions might establish collaborative networks with other schools.	- Struggle to appoint qualified supervisors with the necessary expertise in early childhood education. - Organize inadequate allocation of resources for training, assessment tools, and technology. - Supervision team members disrupt the internal supervision processes. - Some supervisors lead to conflicts or difficulties in	- Appoint qualified supervisors with expertise in early childhood education and supervision techniques. - Provide ongoing professional development to stay updated with the best practices. - Allocate resources to support internal supervision management. - Clarify roles and responsibilities, encourage collaboration, and provide opportunities for team

The present situations	The management problems	The feasible guidelines
	coordinating supervision activities.	members to share insights and expertise. - Encourage cross-functional collaboration by involving educators, administrators, and support staff in supervision teams.
Leading		
- Provide leadership for the professional development of teachers and supervisors - School administrators play a crucial role in providing constructive feedback to teachers and staff based on supervision outcomes. - Encourage a culture of reflection among teachers engaging in self-assessment.	- There might be resistance among educators to receiving feedback from supervisors. - Lack of receiving adequate opportunities for professional development. - Educators and supervisors resist changes in internal supervision practices. - School administrators lack the necessary leadership skills to inspire and motivate teams effectively.	- School administrators should model best practices, provide guidance, and motivate educators and supervisors toward continuous improvement. - Promote specific feedback is used for professional development to teachers and staff. - Invest in ongoing professional development for educators and supervisors. - Implement mentoring and coaching programs within the supervision process.
Controlling		
- Ensure to conduct regular assessments of supervision activities. - Ensure to control of teacher qualifications - Ensure to control the quality of education in accordance with OBEC standards for Early Childhood Education.	- Inadequate monitoring of internal supervision processes. - Challenge to follow standards and national regulations. - Lack of the capability to analyze data comprehensively. - Lack of quality assurance mechanisms. - Restrict the sharing of information. - Lack of evaluation of the outcomes of internal supervision. - Insufficient mechanisms for sharing feedback	- Monitor the implementation of internal supervision plans and assess their effectiveness. - Develop data analysis skills among teachers to identify trends and areas for enhancement. - Establish quality assurance mechanisms. - Maintain a well-functioning feedback loop among supervisors and teachers. - Establish a culture of continuous improvement by regularly reviewing and updating internal supervision processes.

According to the situation of the COVID-19 epidemic, Saengthong, et al. [12] illustrated that the outbreak had a rapid impact on the need for changes in how learning was managed. Both teachers and students were affected because they were unprepared for this new era of education. To address the challenges of teaching and learning, schools turned to the internal school supervision process as a solution. Therefore, it became essential to explore new supervision approaches that aligned with the evolving learning methods. Blended supervision emerged as a promising alternative, suitable for the "new normal" era. It involves a balanced combination of face-to-face and online supervision, leveraging the supportive nature of school staff and creating an effective online supervision platform to enhance the overall effectiveness of supervision.

Similar to the findings of Somrit, Ouppinjai, & Wetcha [13], it revealed that the process of supervision administration in a school involves five steps: 1) supervision

planning, analyzing data, studying problems, educating personnel, implementing the plan, building morale among supervisors, and reporting results. The school's administrative and academic departments lead the supervision process, using various supervisory formats and activities. The results are then used for improvement and joint planning between supervisors to enhance the teaching and learning process.

In line with the guidelines for enhancing educational quality, the school's internal supervision process encompasses various stages. These include initial preparation, identifying responsible individuals and managing the information system, defining roles and responsibilities for both supervisors and those being supervised, creating participatory internal supervision plans, executing the supervision process and implementing the plan, conducting the actual supervision, overseeing the process, conducting follow-up activities, employing various assessment tools for monitoring, evaluating the effectiveness of supervision, concluding the supervision effort, proposing recommendations and solutions, and documenting the supervision in a report. [4]

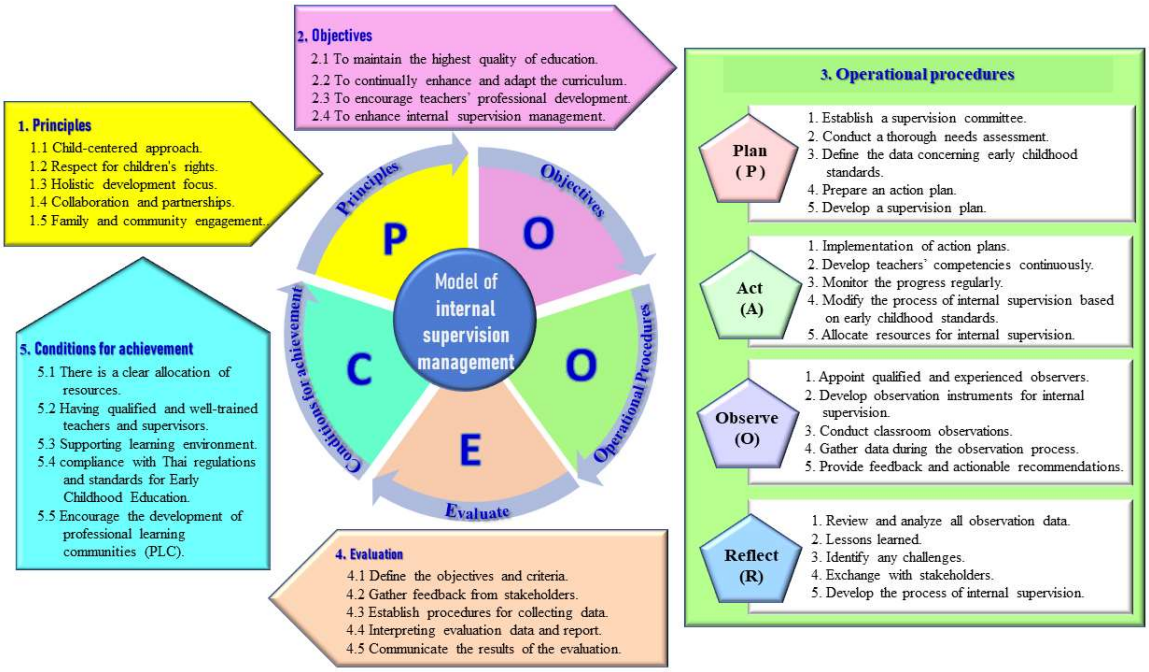

Figure 2: The completed model of internal supervision management according to standards of the early childhood education schools under the OBEC

Phase 3: The development results of a model of internal supervision management according to the standards of the early childhood education schools under the OBEC were as follows:

Step 3.1: A draft model of internal supervision management according to standards of the early childhood education schools under the OBEC consisted of five components: 1) principles, 2) objectives, 3) operational procedures, consisting of 3.1) plan (P), 3.2) act (A), 3.3) observe (O), and 3.4) reflecting (R); 4) evaluation, and 5) conditions for achievement.

Step 3.2: The verification results of the model of internal supervision management according to standards of the early childhood education schools under the OBEC in terms of accuracy was overall at the highest level (95.20 percent) and the

suitability was overall at the highest level (96.54 percent).

The model of internal supervision management according to standards of the early childhood education schools under the OBEC after verifying and correcting is shown in Figure 2.
A model name is POOEC.

The model of internal supervision management according to the standards of the early childhood education schools under the OBEC consisted of five components: 1) principles, 2) objectives, 3) operational procedures of 3.1) plan (P), 3.2) act (A), 3.3) observe (O), and 3.4) reflecting (R); 4) evaluation, and 5) conditions for achievement. The model is in accordance with Runcharoen's [11], proposed in the professional in educational management and administration in the educational reform era, which comprises six essential components: principles, objectives, system and mechanism, operational approaches, evaluation guidelines, and requirements for accomplishment.

Similarly, Ekemezie & & Anyaogu [3] indicated that the responsibilities of school principals in internal supervision to enhance teacher quality and standards encompass several tasks. These include fostering and facilitating teacher growth and development, supporting novice teachers in their professional growth by assisting them in adopting effective teaching methods, promoting extracurricular activities within the school, and ensuring the proper maintenance of financial records. However, various obstacles hinder the effective implementation of quality internal supervision for teacher development. These challenges include some principals' inadequacy in managing certain mandatory records, dealing with an excessive number of senior staff within the school, and the non-employment of lower-ranking teachers, among other issues.

Likewise, Pongsaranuntakul, et al. [6] concluded that enhancing quality through the initial three phases of participatory activities, which involve self-assessment, empowering for change, and revising for improved outcomes, is crucial for preparing individuals in the process to elevate the center's quality to meet sustainable standards. Healthcare professionals can actively contribute to this collaborative development process, leading to the establishment of high-quality childcare centers that ensure preschool children receive appropriate care and experience age-appropriate growth and development.

On the other hand, Kosanpipat, Anussornrajakit, & Kongruang [5], in the early childhood education program at the Faculty of Education, Chiang Mai Rajabhat University, outlined objectives as follows: providing instruction, enhancing comprehensive skills, delivering lessons, conducting research, offering academic services to the community, promoting advancements, sharing knowledge, fostering innovation, preserving arts and culture, producing educators, and elevating the academic standing of instructors.

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6. Conclusion

The model of internal supervision management according to the standards of the early childhood education schools under the OBEC offers several significant benefits. This approach provides a structured and systematic framework for schools, ensuring that they meet and maintain the required educational standards. It promotes professional development among educators and staff, enabling them to continually enhance their teaching and caregiving skills. This model provides a structured framework for schools to ensure and enhance the quality of education and care provided to young children. It helps maintain established standards and regulations, promotes effective teacher development and growth, and facilitates the continuous improvement

of teaching and learning practices. Furthermore, this model facilitates the creation of a safe and nurturing environment for young children, which is essential for their holistic development. By adhering to these standards and utilizing the internal supervision model, Thai early childhood education institutions can ensure the delivery of high-quality education and care to preschoolers, ultimately contributing to their overall growth and development. In summary, the application of the internal supervision management model aligned with the OBEC's standards elevates the quality of early childhood education in Thailand, benefiting both educators and the children they serve.

7. Recommendations

7.1 The development model of internal supervision management according to the standards of the early childhood education schools under the OBEC can be applied to educational management with a quality process.

7.2 The feasible guidelines can be adopted to drive the internal supervision management according to the standards of the early childhood education schools under the OBEC for developing the quality of learners, administrative and management process, and the process of teaching and learning that focuses on child-centered.

8. Recommendation for Further Research

8.1 There should be a study of the development model of internal supervision management according to the standards of the early childhood education schools under the OBEC all over the region.

8.2 There should be a study of an integrated model of internal supervision management according to the standards of the early childhood education schools under the OBEC all over Thailand.

Acknowledgment

Thank you very much to the director and my colleagues of San Mahaphon Wittaya School, Early Childhood School Networks for supporting this research.

References

[1] Bureau of Academic Affairs and Educational Standards, Ministry of Education, Thailand. (2017). Early Childhood Curriculum B.E. 2560 (A.D. 2017). Retrieved from http://academic.obec.go.th/images/document/1572317446_d_1.pdf

[2] Bureau of Educational Testing, Office of the Basic Education Commission. (2018). Guidelines for Quality Assessment by Educational Standards for Early Childhood Education according to the Office of the Basic Education Commission. Retrieved from https://bet.obec.go.th/Bet_Obec/1671

[3] Ekemezie, C. A., & Anyaogu, A.G. (2021). Principals and Internal Supervision for the Development of Teacher Quality and Standards in Secondary Schools in Abia State UNIJERPS, Unizik Journal of Educational Research and Policy Studies, (3); https://unijerps.org/index.php/unijerps/article/download/44/40

[4] Kanyayon, S. (2021). Guidelines for Development of Educational Quality Through Internal Supervision Process of Wat Ku Kham Municipality School, Chiang Mai Province. Journal of Buddhistic Sociology, 6(1), 51-62 https://so06.tci-thaijo.org/index.php/BSJ/article/download/244132/168079/873938

[5] Kosanpipat, S., Anussornrajakit, H., & Kongruang, S. (2023). Research and development of roving team network to support the competency-based production process of quality teachers in the early childhood education program, Faculty of Education, Rajabhat University: A case study Chiang Mai Rajabhat University. Interdisciplinary Research Review, 18(3).

Retrieved from https://ph02.tci-thaijo.org/index.php/jtir/article/view/247220

[6] Naksorn, S., Kosanpipat, S., Suwatthee, P., & Boonchai, T. (2022). The Components of Internal Supervision Management According to Standards of the Early Childhood Education Schools under the Office of the Basic Education Commission. Refereed Proceedings of the 18th. National Academic Conference and Research Presentations, Western University (pp. 189-105).

[7] Office of the Basic Education Commission. (2019). Ministry of Education. Early Childhood Education Standards for Internal Quality. Retrieved from

http://thesis.swu.ac.th/swupam/Ed_St_P151249.pdf

[8] Office of the Education Council. (2017). National Scheme of Education B.E. 2560-2579 (2017-2036). Retrieve from http://www.onec.go.th/index.php/book/BookView/1540

[9] Pongsaranuntakul, Y., Rungamornarat, S., Nookong, A., & Supchareonmak, L. (2021). Quality Improvement Model for Early Childhood Development Center: A Case Study of Child Development Center under Bangkok Metropolitan Administration. Nursing Science Journal of Thailand, 39(3), 91–105. Retrieved from https://he02.tci-thaijo.org/index.php/ns/article/view/248975

[10] Royal Thai Government Gazette. (2017). Thailand's 20 – Year National Strategy. (2017-2036). Retrieve from http://www.ratchakitcha.soc.go.th/DATA/PDF/2561/A/082/T_0001.PDF

[11] Runcharoen, T. (2010). Administration for Learning Reform. Bangkok: Khaofang: Publishing

[12] Saengthong, W., Klungklang, W., Sawaengphon, A., Masena, C., & Chouranong, N. (2022). Internal School Supervision in the New Era : How to Supervise Teachers in the New Normal Era. Journal of Graduate School, Pitchayatat, Ubon Ratchathani Rajabhat University, 17(1), 123–133. Retrieved from https://so02.tci-thaijo.org/index.php/Pitchayatat/article/view/252502

[13] Somrit, W., Ouppinjai, S., & Wetcha, P. (2021). THE GUIDELINES a guideline for school supervision management in learning management. Under the Office of Phayao Primary Educational Service Area 2. Journal of MCU Phetchaburi Review, 4(1), 1–14. Retrieved from https://so03.tci-thaijo.org/index.php/JPR/article/view/253012

[14] UNICEF. (2022). UNICEF Thailand Early Childhood Development 2022-2026 Retrieved from https://www.unicef.org/thailand/media/9671/file/UNICEF_Thailand_ Country_Programme ECD_EN.pdf