Interdisciplinary Research Review

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Editorial Note

The Interdisciplinary Research Review (IRR) was established with academic cooperation by the Nakhon Pathom Rajabhat University, The Royal Society of Thailand Committee of Interdisciplinary Research and Development, Rajabhat University (Western Group), and Rajamangala University of Technology Rattanakosin. This Issue, Volume 17 Number 4 (July – August 2022). This issue contains of five interesting articles in multidisciplinary fields: (1) Achievement goals, emotions, and failure tolerance: Path model of students' mathematics motivation, (2) Enhancing vocabulary among grade 4 deaf and hard-of-hearing (DHH) learners through an online sign language intervention: A mixed method study, (3) Developing a structural equation model: Case study of Thai port developing, (4) Travelers, merchants, and foreigners appeared in facial stucco sculptures in Dvaravati humans in Nakhon Pathom Province, and (5) Low-heat sterilization system on fruit and vegetable pickling line production in packaging with high-voltage and corona-ozone technique.

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.

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Yongyudh Vajaradul
Editor
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Achievement goals, emotions, and failure tolerance: Path model of students' mathematics motivation

Avelino G. Ignacio Jr.[1,*]

[1]**College of Education, Bulacan State University, Philippines**

Abstract

The purpose of this research paper is to decompose effect patterns comprising achievement goals, emotions, and academic failure tolerance in a single path model from a mathematics perspective. Teacher-education undergraduates from the College of Education of Bulacan State University, Philippines (N = 261) got via multistage sampling accomplished the self-report measures online: Achievement Goal Questionnaire, Achievement Emotions Questionnaire, and School Failure Tolerance Scale. Structural equation modeling was used to assess the research model. Results showed that the modified structural model indicators have good construct reliability, convergent validity, and discriminant validity, having an adequate fit, supporting several hypotheses. Findings showed that approach goals positively impact positive emotional pride, and negatively impact negative outcome emotions. Negative outcome emotions impact fear and discouragement after making errors on tasks they are trying to learn. Interpersonally defined avoidance goals yield low negative activity emotions. The path model offered a cleaner picture of the results.

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1. Introduction

Learners usually give attention to tough topics at their own pace as long as they see themselves learning [1]. However, when context-specific academic-related drawbacks arise and are assumed to carry on through failure, complex developments may emerge [2, 3]–stirring achievement goals [4, 5], achievement emotions [6], and failure tolerance [7, 8] which when not addressed, may limit the ability to appraise necessary options for structuring desired outcomes [9, 10]. Upholding clear achievement goals orient students to focus on their progress rate, paying less weight to subjectively trivial ones [11, 12], which affects emotional inputs and academic preferences [13 – 15]. The amount of failure tolerance placed in schools powerfully predicts risk-taking on tasks that trigger self-enhancement goals [16 – 18], promoting mathematics efficiency [3]. That is, although the students may be extrinsically motivated by grades and by this means want to succeed in various mathematics-related activities and learning outcomes, they may still experience difficulties in pursuing their academic goals, motivational glitches concerning willingness and ability to remain focused, and on tasks in their mathematics studies. Consequently, teachers, in the pursuance of enhancing motivation towards mathematics learning, should be definite about how students' academic orientations, feelings, and failure tolerance vary and are linked to address the needs of students and eventually assist them in academic growth [19, 20]. Thus, the main goal of this research paper is to decompose effect patterns comprising achievement goals, emotions, and academic failure tolerance in a single path model. This research contributes to the achievement motivation research in mathematics.

2. Literature and Hypotheses

2.1 Achievement goals

Achievement goals (AGs) are mental images of intrapersonally or interpersonally stirred competence-based preference one seeks to attain [4, 21]. This preference can be chosen and later be valued according to definition and valence [4, 14]. In terms of definition, we have intrapersonal or interpersonal; in terms of valence, positive or negative [5, 22]. AGs theorized four types-mastery-approach (MAp), mastery-avoidance (MAv), performance-approach (PAp), and performance-avoidance (PAv) [4, 5]. MAp focuses on refining knowledge; MAv concentrates on avoiding misunderstanding; PAp centers on showing good relative performance; and PAv engages in preventing looking worse [21]. MAp and MAv are intrapersonal, while PAp and PAv are interpersonal. MAp and PAp are positive, while MAv and PAv are negative [22].

2.2 Achievement emotions

Achievement emotions (AEs) are formed when students assume subjectively valued outcomes and activities in or out of control [23 – 25]. AEs propose three-dimensional taxonomy: valence-activation-object focus [25]. The valence splits positive (e.g., pride and enjoyment) and negative (e.g., hopelessness, boredom, anxiety, shame, and anger) emotions. The activation splits activating (e.g., shame, anger, pride, anxiety, and enjoyment) and deactivating (e.g., boredom and hopelessness)

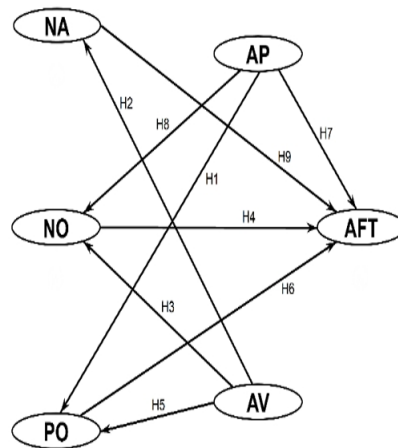[*]Corresponding author; email: avelino.ignaciojr@bulsu.edu.ph

Figure 1: Research model
Notes: NO negative-outcome emotion, NA negative-activity emotion, PO positive emotion, AP approach goal, AV avoidance goal, and AFT academic failure tolerance

emotions. The 'object focus' separates activity (e.g., enjoyment, boredom, and anger) from outcome (e.g., retrospective outcome pride and shame; prospective outcome hopelessness and anxiety) emotions [26 – 30].

2.3 Academic failure tolerance

As Kim and Choi [8] defined: "Academic failure tolerance (AFT) is a characteristic that responds positively and constructively to failure in an academic situation." This indicates constructive resistance to current failures. From constructive failure theory, AFT varies depending on how the students respond to and are conscious of personal goals and available assessment and evaluation [3, 31]. With an amount of grit rising from clear responses to valued goals and available evaluation, students are assumed to increase effort after failure by using tougher constructive efforts on tasks that trigger self-enhancements [16, 32].

2.4 Research model

For the research model (see Figure 1), the latent variables are shown with an oval-NO negative-outcome emotion, NA negative-activity emotion, PO positive emotion, AP approach goal, AV avoidance goal, and AFT academic failure tolerance. The single-headed arrows specify the structural relationship between variables labeled by the research hypotheses.

Recent studies offer evidence as to the links of the key constructs. Approach goals are reported to have positive paths to enjoyment, pride, and hope; whereas avoidance goals, in general, posit significant paths to anger and boredom; while there are paths to hopelessness and shame when interpersonally stimulated; whereas shame has links to fear of failure [6, 15, 33 – 36].

H1: AP has a significant positive impact on PO.
H2: AV has a significant impact on NA.
H3: AV has a significant impact on NO.
H4: NO has a significant negative impact on AFT.

Interpersonally stirred avoidance goals are linked negatively to pride and hope [23]. When attached to challenge appraisals, approach-oriented hope and enjoyment lead to higher amounts of engagements [25, 35, 37], while approach goals are linked negatively to shame and hopelessness [23]. Low boredom, great pride, and enjoyment are more likely to incite better efforts after failure when academic control has been found [38, 39].

H5: AV has a significant negative impact on PO.
H6: PO has a significant positive impact on AFT.
H7: AP has a significant positive impact on AFT.
H8: AP has a significant negative impact on NO.
H9: NA has a significant negative impact on AFT.

3. Methods and Materials

3.1 Design and data collection

This study used structural equation modeling (SEM) [40]. SEM combines path analysis to develop a structural model with latent variables and factor analysis to test causal theories comprising multifaceted constructs measured with error. To determine the sample size, this research followed the recommendation of Hair *et al.* [40] involving an SEM study with seven or fewer constructs-a minimum sample size of 150, got via multistage sampling [41]. Voluntarily, the participants included undergraduate students of the Bulacan State University-College of Education (N = 261), located in Bulacan, Philippines, enrolled in the school year 2020 – 2021. Specifically, 177 Bachelor of Secondary Education (67.8%) and 84 Bachelor of Technical and Livelihood Education (32.2%) students were used, in which 61 (23.4%) and 200 (76.6%) were males and females, respectively.

The researcher asked for approval from the college dean to conduct the study and moved to the actual survey after getting approval. The survey was distributed via Google Forms. As to ethical considerations, informed consent, respect for confidentiality and anonymity, and voluntary participation were observed. The researcher clarified all essential matters about the study in the first section of the Google Forms survey and asked to confirm voluntary involvement using a consent form. Participants must have voluntarily filled out the consent form before answering the survey. The students were given ample time to reply. The data were transferred in a spreadsheet afterward.

Table 1. Goodness of fit and fit indices of the measurement model.

Model	m	χ^2	df	χ^2/df	CFI	TLI	RMSEA	Overall Model Fit
1	108	11421.58***	5655	2.02	.56	.55	.08	Inadequate
2	19	215.90***	137	1.58	.96	.95	.06	Adequate

Notes: ***$p < .001$; m number of measured variables. The threshold values are as follows: χ^2 ($p > .05$); χ^2/df (≤ 3); CFI ($\geq .95$); TLI ($\geq .95$); RMSEA ($\geq .08$). In case χ^2 is significant at $p < .001$, χ^2/df is referred [40].

Table 2. Convergent validity and construct reliability of the measurement model.

Latent Variables	Measured Variables	Convergent Validity		Construct Reliability	
		Loadings ($\geq$.70)	AVE ($\geq$.50)	CR ($\geq$.70)	α ($\geq$.70)
NO	Ho1	.800***	.651	.929	.928
	Ho3	.786***			
	Ho4	.830***			
	Ax10	.777***			
	Ax14	.823***			
	Sh6	.808***			
	Sh7	.822***			
NA	Br2	.766***	.655	.791	.787
	Ag4	.851***			
PO	Pr1	.901***	.839	.913	.912
	Pr2	.931***			
AFT	Af10	.756***	.619	.764	.762
	Af12	.816***			
AV	Pv1	.780***	.674	.861	.859
	Pv2	.852***			
	Pv3	.829***			
AP	Mp1	.758***	.626	.834	.833
	Pp1	.816***			
	Pp2	.799***			

Notes: ***$p < .001$; AVE average variance extracted; CR composite reliability; α alpha. Threshold values are placed below each indicator. Attributes of estimators for construct reliability and convergent validity were adapted from *Multivariate Data Analysis* by Hair *et al.* [40].

3.2 Measures

Achievement Goal Questionnaire (AGQ) [42], Achievement Emotions Questionnaire - Mathematics (AEQ-M) [30], and School Failure Tolerance Scale (SFT) [16] were used. AGQ has 12 items–three items reflecting each AG, evaluated on scales from 1 (not all true of me) towards 7 (very true of me). AEQ-M has 60 items–pride (6), enjoyment (10), boredom (6), anger (9), anxiety (15), hopelessness (6), and shame (8). Items are evaluated on scales from 1 (strongly disagree) to 5 (strongly agree). Lastly, SFT has 36 items, evaluated from 1 (strongly disagree) to 5 (strongly agree). Ignacio [29] offered evidence on the reliability of AGQ and AEQ-M, with $\alpha_{agq} \geq .76$ and $\alpha_{aeq} \geq .71$; while Clifford [16] stated SFT with $\alpha_{sft} \geq .80$. Reverse-coded SFT items are recoded, inferring high failure tolerance on a high score.

3.3 Data analysis

The researcher defined the latent variables specifying relevant scales. Secondly, unengaged responses were removed through standard deviation. Thirdly, confirmatory factor analysis (CFA) [40] was used to assess the models' fit, reliability, and validity and respecify the model. Fourthly, the structural model was modified using fit and modification indices, observing a priori knowledge for relevance. Lastly, after getting an adequate structural model, each path was tested. All significant paths were analyzed.

4. Results and Discussion

4.1 Model respecification

The overall fitness of the model was estimated based on the goodness of fit statistic and fit indices– χ^2 chi-squared statistic; χ^2/df normed chi-square; CFI comparative fit index; TLI Tucker-Lewis index; and RMSEA root mean square error of approximation (see Table 1) [40]. The respecified measurement model[2] (see Figure 2) fits the data adequately, in particular, $\chi^2(137) = 215.90$, $\chi^2/df = 1.58$, CFI = .96, TLI = .95, RMSEA = .06.

From Figure 2, all measured variables have standardized factor loadings greater than or equal to .76; all error variances are less than or equal to .43. More than half of the variation in an item is explained by their corresponding latent factor assessed
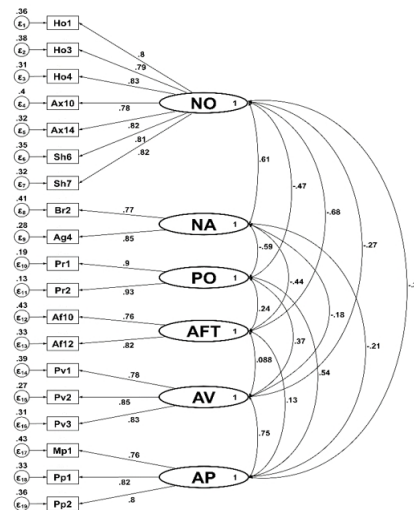
Figure 2: Measurement Model

Notes: NO negative-outcome emotion, NA negative-activity emotion, PO positive emotion, AP approach goal, AV avoidance goal, and AFT academic failure tolerance

Table 3. Discriminant validity of the measurement model.

	Mean	SD	1	2	3	4	5	6
1. NO	3.22	1.21	.807					
2. NA	1.89	0.91	.608	.809				
3. PO	3.45	1.01	−.469	−.586	.916			
4. AFT	2.60	1.15	−.679	−.444	.239	.787		
5. AV	5.42	1.14	−.267	−.178	.366	.088	.821	
6. AP	5.39	1.16	−.307	−.208	.538	.130	.746	.791

Notes: SD standard deviation; diagonal elements (in bold) present the square root of AVE; off-diagonal entries show the latent correlations. Positive correlations move together, while negative correlations move inversely. The diagonal entries must be higher than the absolute value of any off-diagonal entries to establish discriminant validity. The Fornell-Larcker criterion was adapted from Fornell & Larcker [44].

using the variance extracted. The covariances between distinct latent variables are less than or equal to .75. While Hair *et al.* [40] suggested that latent constructs are to be specified by at least three measures, the conscientious use of at least two but best indicators is sufficient in SEM [43], allowing the use of two measured variables for the NA, PO, and AFT.

From Table 2, all factor loadings are greater than or equal to .76. The average variance extracted (AVE) on each latent construct is greater than or equal to .62. For CR and a, all values are greater than or equal to .76. Hence, the measured variables of each latent construct converge an acceptable amount of explained variance, thus, reliably and validly representing the same latent construct. Table 3 specifies the extent to which a latent construct is distinct from others via the Fornell-Larcker criterion [44]. The square root of the AVE is higher than any latent correlations, showing discriminant validity–each latent variable is distinct from the others. Accordingly, the model's indicators have been established (see Appendix).

4.2 Structural model modification

The overall fitness of the structural model was estimated based on the goodness of fit statistic and several fit indices (see Table 4). The same set of indicators defined earlier was used to test the fit of the structural model [40]. The modified struc-

tural model[2] fits the data adequately with $X^2(125) = 198.77$, $X^2/df = 1.59$, CFI = .96, TLI = .95, RMSEA = .06.

4.3 Path analysis and hypothesis testing

Table 5 specifies the paths supported and not supported by the modified structural model.

Significant Path AP→PO

The magnitude of determination the students place to thoroughly master the material presented in math class (Mp1) as well as to perform well in proportion to other students (Pp1, Pp2) meaningfully impacts the amount of positive emotion–pride (Pr1, Pr2). The more the students simultaneously aim to master the material (Mp1) and perform well interpersonally (Pp1, Pp2) in consequence of thinking deeply about competence as fulfilling and appealing [22], the more the students consciously form a sense of pride in their knowledge and contributions to the math class (Pr1, Pr2).

Significant Paths AP→NO and NO→AFT

The lesser attention the students place on improving their mathematical knowledge and understanding and demonstrating their ability to others induces negative-outcome emotions. Before taking a math test, the students feel down (Ho1), keep thinking that they do not understand the material (Ho3) and that they may never get good grades (Ho4), in addition to feeling
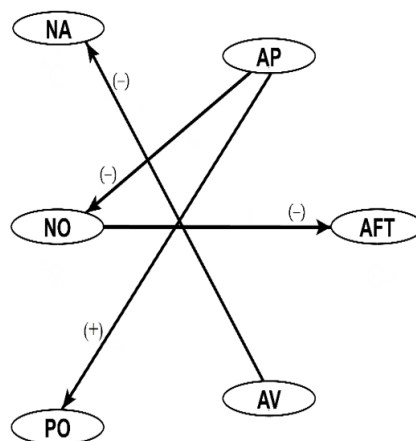
Figure 3: Final Path Model

Notes: NO negative-outcome emotion, NA negative-activity emotion, PO positive emotion, AP approach goal, AV avoidance goal, and AFT academic failure tolerance

Table 4. Goodness of fit and fit indices of the structural model.

Model	χ^2	df	χ^2/df	CFI	TLI	RMSEA	Overall Model Fit
1	385.42***	143	2.70	.87	.85	.10	Inadequate
2	198.77***	125	1.59	.96	.95	.06	Adequate

Note: ***$p < .001$

sick to their stomach, suggesting feeling troubled and worried (Ax14). While taking a math test, students worry they might get a bad grade (Ax10). It can be observed that the future outcome of any effort to gain academic control before and while taking a math test can be subjectively thought of as uncertain, either favorable or unfavorable [25]. After taking a math test, students feel ashamed (Sh7). Likewise, they avoid eye contact when discussing the homework assignments with their classmates (Sh6). Here, the negative-outcome emotion can be attributed to their personal interpretation of the possible causes of past outcomes [45]. The inadequacy of grit [32] to completely master the material and to perform well compared to others (Mp1, Pp1, Pp2) [21] impacts negative-outcome emotions (hopelessness and anxiety due to uncertainty of future outcomes and shame due to the subjective interpretation of the possible causes of past outcomes, either caused by the self, other people, or external circumstances) [25, 45].

The negative-outcome emotion is specified as having a significant negative effect on academic failure tolerance. Items Af10 and Af12 are reverse items and were recoded during the data analysis. Thus, the more the students hold negative-outcome emotions, the more discouraged they get after committing errors on tasks they are trying to learn (Af10) and feel terrible after giving wrong answers to a teacher's question (Af12). It must be pointed out that the indirect path AP→NO→AFT is not significant. NO does not meaningfully influence variations in AP→AFT, although AP→NO and NO→AFT are significant.

Significant Path AV→NA

The extent of prevention the students put to avoid looking slow, performing worse, and doing poorly in proportion to other students (Pv1, Pv2, Pv3) influences the extent of negative-activity emotion-boredom and anger (Br2, Ag4) in a sufficiently meaningful way. As the students attempt to avoid doing worse than the others entirely (Pv1, Pv2, Pv3), they become more focused, so much that their boredom (Br2) and irritation during math class (Ag4) diminishes. While this path is significant, this result contradicts one of Linnenbrink-Garcia & Barger's [23] findings. The result of the present study involving undergraduate education students confirmed that the performance-avoidance goal (Pv1, Pv2, Pv3) relates negatively to negative-activity emotion (Br2, Ag4). As stated by Pekrun *et al.* [45]: "... boredom is induced when the activity lacks any incentive value" (p. 38). Inversely, anger is induced when the subjective value of achievement-related activities is high [25] (p. 320). It can be stated that the central focus is on action for boredom and anger, not on outcomes [25] (p. 319). Therefore, strong performance-avoidance goals that satisfy students' actions and engagements in math class (Pv1, Pv2, Pv3) meaningfully yield low boredom (Br2) and low anger (Ag4).

5. Conclusion

The present research findings attest to the reliability and validity of the respecified measurement model (see Figure 2). The findings show that the indicators (see Appendix) are good and are well-suited for their purpose. The modified structural model[2] (see Table 4) utilized fit and modification indices and a priori knowledge in refining its overall fit. Findings show that the students who simultaneously aim to master the material presented in math class and do well relative to others consciously feel pride for their knowledge and contributions to the math class, or else negative-outcome emotions may occur. When future outcomes are seen as uncertain or by any means are associated with subjective causes of their past outcomes, students who are making an effort to learn some materials presented in the math class, if faced with academic-related drawbacks,

Table 5. Hypothesis testing.

Hypothesis	Hypothesized Path	Loadings	*p*-value	Decision
H1	AP→PO	.459	.000	Supported
H2	AV→NA	−.183	.039	Supported
H3	AV→NO	−.128	.190	Not Supported
H4	NO→AFT	−.797	.000	Supported
H5	AV→PO	.101	.296	Not Supported
H6	PO→AFT	−.058	.656	Not Supported
H7	AP→AFT	−.053	.617	Not Supported
H8	AP→NO	−.251	.006	Supported
H9	NA→AFT	.169	.264	Not Supported

Notes: NO negative-outcome emotion, NA negative-activity emotion, PO positive emotion, AP approach goal, AV avoidance goal, and AFT academic failure tolerance

both discouragement and fear of committing errors preoccupy their minds. Strong performance-avoidance goals that satisfy students' actions in the math class produce low boredom and low anger. The final path model (see Figure 3) utilizing the achievement goals, emotions, and failure tolerance constructs presented a more straightforward and cleaner picture of the findings, bearing in mind the indicators of the modified structural model.

6. Recommendation

The researcher initially tried to assess the fit, reliability, and validity of each construct existing in the literature but was unsuccessful due to low construct and discriminant validity and thus ended up with six constructs through item parceling. The study included teacher education students. In connection to this, the researcher recommends using a more diverse set of samples to acquire more information comprising indirect effects and not ending up with item parceling.

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Appendix. Indicators of the modified measurement model

LV	MV	Indicators
NO	Ho1	I feel down.[**b]
	Ho3	I keep thinking that I don't understand the material.[**b]
	Ho4	I keep thinking that I will never get good grades in mathematics.[**b]
	Ax10	When taking the math test, I worry I will get a bad grade.[**d]
	Ax14	When I have an upcoming math test, I get sick to my stomach.[**b]
	Sh6	When I discuss the homework assignments with my classmates, I avoid eye contact.[*d]
	Sh7	After taking a test in mathematics, I feel ashamed.[**a]
NA	Br2	I can't concentrate because I am so bored.[***d]
	Ag4	I get irritated by my math class.[***d]
PO	Pr1	I think I can be proud of my knowledge in mathematics.[***a]
	Pr2	I am proud of my contributions to the math class.[***a]
AFT	Af10	I get very discouraged if I make errors on a task I am trying to learn.[****]
	Af12	If I give a wrong answer to a teacher's question, I feel terrible.[****]
AV	Pv1	My aim is to avoid doing worse than other students.
	Pv2	I am striving to avoid performing worse than others.
	Pv3	My goal is to avoid performing poorly compared to others.
AP	Mp1	My aim is to completely master the material presented in this class.
	Pp1	My aim is to perform well relative to other students.
	Pp2	I am striving to do well compare to other students.

Notes: LV latent variables; MV measured variables; NO negative-outcome emotion, NA negative-activity emotion, PO positive emotion, AP approach goal, AV avoidance goal, AFT academic failure tolerance; [**b] emotion experienced before taking a math test; [***d] emotion experienced while taking a math test; [**a] emotion experienced after taking a math test; [*d] emotion experienced while studying or doing homework in math; [***d] emotion experienced while being in math class; [***a] emotion experienced after being in math class; [****]reverse coded item.

Enhancing vocabulary among grade 4 deaf and hard-of-hearing (DHH) learners through an online sign language intervention: A mixed method study

Jordan S. Madronio[1,*]

[1] **Department of Education (DepEd), Philippine School for the Deaf, Philippines**

Abstract

Filipino Deaf and Hard-of-Hearing (DHH) learners are generally considered bilingual who use Filipino Sign Language (FSL) as their primary mode of communication. Written language in Filipino or English form-part of their secondary mode of communication but the DHH learners' familiarity with the English written language is evident due to the influence of the American Sign Language (ASL). There is a challenge among grade 4 DHH pupils to remember Filipino-written *Araling Panlipunan* (Social Studies) vocabularies and their corresponding manual sign. The overall purpose of this study is to address the difficulties encountered through an intervention called *Araling Panlipunan* (AP) Filipino Sign Language (AP-FSL). The intervention is in the form of multimedia learning resource material that is made accessible for any Android or iOS device. The study used mixed method approach in collecting quantitative and qualitative data. Quantitative data were gathered through the conduct of pre and posttest to thirty (30) grade 4 learners while the qualitative data were collected through survey forms and semi-structured interviews. Results revealed a significant increase in the mean percentage score from 9.33 to 83.47. Post test result fell under the independent reading level. The overall impression or rating of the stakeholders to the AP-FSL intervention was "strongly agree" which implies that an intervention to increase the AP vocabularies among DHH learners is strongly recommended. Stakeholders' recommendation to further enhance the intervention were also taken into consideration highlighting the importance of close collaboration with the Filipino Deaf community in utilizing appropriate manual sign in AP lessons.

Keywords: deaf and hard-of-hearing education, Filipino Sign Language, multimedia, social studies

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1. Introduction

In 2015, UNESCO, in its call for functional literacy, initiated the Education for All (EFA). This initiative included provisions to ensure all Filipinos to achieve the ability to read, write and do calculations at a level that is sufficient for the country in which a particular person lives [1]. Through this endeavor, the deaf and hard-of-hearing (DHH) pupils who have unique learning characteristics are included. Considering that they are bilingual and visual learners, sign language serves as their primary language while written language, in Filipino or English, as their second language. Among the two written languages, they are more versed in English because of the American Sign Language (ASL) influence [2].

Numerous studies have indicated that DHH children have significantly delayed vocabulary and reading comprehension, literacy skills, and overall depressed academic achievement in general when compared to their hearing peers [3]. Since their primary acquisition of learning is through their sense of sight, appropriate learning materials should be utilized to suit their learning needs. It may include pictures, images and video clips with sign language interpretation.

Computer-based interventions are conducted to improve DHH learners' vocabulary, literacy and comprehension skills.

Previous studies examined the applicable format via computerized programs containing combinations of picture, print and interactive content [4, 5]. Study conducted by Reitsma [6] focused on the utilization of video with sign language, printed words and drawings for 6 to 9 year-old deaf learners. Results indicated that drawings were most effective in increasing word identification, spelling, and reading comprehension. However, in a study conducted by Holmer, Heiman, and Rudner [7], they concluded that computerized interventions that utilize sign language, on either word reading or reading comprehension, have no significant effect. In the said study, regarding the three variables, namely, (a) sign language phonological awareness, (b) sign language comprehension, and (c) non-linguistic working memory, no significant effects were found.

In other reviews on the interventions using computer-based applications and captioning, they reveal that when lectures were presented to DHH students through the use of sign language, these students were found to comprehend more the content of the lectures. However, they tend to understand better and become more attentive when the lecture materials being provided to them are aided with captions and visual cues [8] [9]. These findings align with those studies focused on comprehension for reading and mathematics. Students with hearing loss seemed to benefit the most when a combination of print and visual representations such as pictures or photos were used [10] or when captions were paired with an American Sign Language

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*Corresponding author; email: jordan.madronio@deped.gov.ph

(ASL) video [10, 11] to present instructional material. Student engagement and performance were greatly improved when instruction was paired with scaffolding software [12].

Multiple studies used computer-based multimedia applications in teaching learners with hearing loss [10, 13, 14]. Researchers Jackson, Gaudet, McDaniel and Brammer [15] stated that the use of multimedia technology, including synchronous text-talking media can enhance learning and promote the acquisition of information at all levels through multiple modalities and immediate feedback. This use of technology is seen as very crucial in accommodating the diverse styles of learning which would allow educators to structure educational activities creating positive learning environment, effective interaction, communication, critical and higher-level thinking among DHH learners. Multimedia computer programs, applications and digital media present a combination of both verbal and visual information, including pictures, video, and models such as concept maps to introduce new vocabulary and grammatical concepts. These types of programs have proven to increase recall, and retention of information over information presented in only one form [11]. Hamilton [16] conducted a study titled, "The Efficacy of Dictionary Use while Reading for Learning New Words," which suggested that DHH students may benefit from the use of electronic bilingual multimedia English-American Sign Language (ASL) dictionaries to build vocabulary during independent reading.

Mayer [17] refers multimedia learning as the learning from both words and pictures. Visual learners highly preferred a well-designed multimedia that contained pictures, words, and interactive features than the traditional "words model" alone. Mayer's theory assumed that successful multimedia learning was dependent on the ability of a person in selecting words and pictures, and integrating prior knowledge stored in long-term memory. Mayer's cognitive theory of multimedia learning was based on three assumptions. First, the human information processing system consists of two separate channels, verbal channel for processing verbal representations and a pictorial channel for processing visual representations. Second, the channel in the mind, limited in the amount of materials, can process at any one information at a time; and the third assumption stated that meaningful learning can occur when pupils were engaged in active processing within the channels. People learn thoroughly from words and pictures rather than from words or pictures alone [18]. By combining text, pictures and illustrative video, learners could make assumptions or explain the picture through their prior knowledge.

During the time of COVID-19 pandemic, where the traditional classroom set up is not possible, the use of multimedia and pre-recorded video lessons was widely practiced for knowledge acquisition of DHH learners. However, this intervention was not enough for them to fully understand the Filipino-written sentences. Blended Learning is the Department of Education's (DepEd) response to the COVID-19 pandemic. DepEd defined it as face-to-face with any or a mix of online distance learning, modular distance learning, and TV/Radio-based Instruction [19]. In the case of the Philippine School for the Deaf (PSD), the country's pioneer, semi-residential and sole government-owned institution f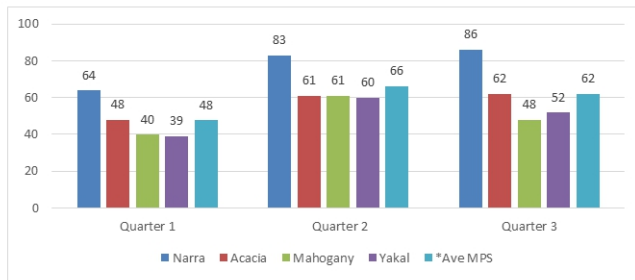or learners who are deaf and hard of hearing (DHH) [20], learning delivery was primarily through the combination of modular and online synchronous/asynchronous sessions. PSD is an integrated school located in the Schools Division of Pasay City along FB Harrison Street and offers K-12 curriculum of the Department of Education (DepEd). It uses total communication as a mode of teaching delivery [21].

Prior to the pandemic, lessons in *Araling Panlipunan* (AP) were adapted using sign language and written English as modes of teaching strategy. The school year 2020-2021 was the pilot year of using Filipino as the mode of instruction delivery in *Araling Panlipunan* (Social Studies) or AP in the elementary department. *Araling Panlipunan* is a field of study which focuses on human connections and how society functions. It is a portion of the basic education curriculum that includes lessons in history, government, economics, civics, sociology, geography, and anthropology and is focused on the study of social relationships and the functioning of society. Government schools in the Philippines use Filipino language in teaching this subject area. AP is commonly taken from the first year to the fourth year of high school in the old Basic Education Curriculum. In Grades I to III, this is referred to as *Sibika at Kultura* (Civics and Culture); and in Grade IV to VI, it is called HEKASI or *Heograpiya, Kasaysayan at Sibika* (Geography, History and Civics). With the implementation of the K to 12 Basic Education Program, *Araling Panlipunan* is already included in Grades I to VI curriculum. The study of AP in basic education is integral in the development of pupils, whom the government envisions to become socially aware, actively involved in public and civic affairs, and contribute to the development of a progressive, just, and humane society [22]. The shift from English to Filipino language created a challenge among grade 4 DHH pupils in remembering AP vocabularies and the corresponding manual sign.

Grade 4 pupils in PSD were grouped into sections that composed of 10 learners. Section names were derived from the trees found in the Philippines that have stunning features. Trees like Acacia, Narra, Mahogany and Yakal were the designated names for each section. The DHH learners were made aware that these trees are found in the country's forest, and prevalently being used in the process of furniture making [23].

Figure 1 reveals the level of performance of grade 4 in AP from the previous school year 2019-2020 gathered from the results of the teacher-made quarterly examinations. A fourth quarter examination was not administered due to the Covid-19 outbreak in the last quarter of the aforementioned school year [24]. It can be implied from the graph that there was a low performance of grade 4 DHH learners in AP particularly during the first quarter. Section Narra showed an above 80% MPS for the 2nd and 3rd quarters. Three sections namely, Acacia, Mahogany and Yakal, garnered a below 50% MPS from the first quarter. For the succeeding quarters, a below 61% performance was recorded.

The grade 4 sections were reduced into 3, namely, Narra, Mahogany and Yakal. Figure 2 shows the level of performance of Grade 4 DHH pupils during the blended distance learning through the summative tests conducted during first, second, third and fourth quarters of the school year 2020-2021. The data presented were collected from the teacher-made summa-

MPS- mean percentage score

Figure 1: Grade 4 Consolidated Test Results (SY 2019 – 2020)

MPS-mean percentage score

Figure 2: Grade 4 Consolidated Summative Test Results (SY 2020 – 2021)

Figure 3: Components of the APFSL intervention

Table 1. Profile of the participants in the evaluation of AP-FSL.

Participants	Age	Gender	Profession	Hearing Ability/Loss
A	12	Male	Pupil	Profound
B	47	Female	Parent	Regular Hearing
C	25	Female	Deaf teacher	Profound
D	38	Female	Teacher	Regular Hearing

2. Research Questions

2.1 What is the level of AP vocabulary of the Grade 4 DHH learners before and after the AP-FSL intervention?

2.2 Is there a significant difference before and after the AP-FSL intervention in the sign language skills of Grade 4 DHH learners in AP vocabularies?

2.3 What are the challenges, perceptions, and opinions of the stakeholders in the implementation of the AP-FSL intervention?

HYPOTHESIS (HO)

There is no significant difference in the mean percentage scores of the grade 4 pupils before and after the utilization of the AP-FSL intervention in increasing the pupils' sign language skills in AP vocabularies.

3. Methodology

In this research endeavor, mixed method approach was utilized which involved quantitative and qualitative data collection [27]. Quantitative research was employed in the pre and post-test of the participants. The qualitative part, on the other hand, was utilized to gather perceptions, insights and opinions through survey and semi structured interview from selected stakeholders.

3.1 Population and samples

The participants in this study were 30 grade 4 DHH learners of PSD who were enrolled in the school year 2020-2021. Twenty-one or 70% were male and nine or 30% were female. The study presupposes the predominance of male more than female. Participation rate was at 100% which represents the entire grade 4 population of PSD during the said school year.

Purposive sampling method was used to select stakeholders to represent learners, parents, teachers and the deaf community. Table 1 summarizes their profile in terms of age, profession and hearing ability/loss.

3.2 Research instruments

For the quantitative part, the pre-test and post-test scores were collected to determine the level of their vocabulary skills in AP. The study adapted the "Reading Level Proficiency Rubric" of the Philippine Informal Reading Inventory (Phil-IRI) to measure and describe the level of vocabulary of the pupils [28]. The scores of each participant were recorded in the Level of Vocabulary Proficiency Form to determine their

tive examinations. Despite the modifications made in the test questions, it still revealed a noticeable decrease in the grade 4 DHH learners' summative test results in AP. The highest MPS average was recorded during the first quarter at 73% while the lowest in the last quarter was at 53%.

One of the factors that might have affected their performance was the shift from English to Filipino written language in the delivery of instruction. Another factor could be due to the school calendar adjustments. It can be recalled that DepEd adjusted its school calendar of activities and added two weeks to compensate the adjustment made in the school year 2020 – 2021 [25]. Initially, the school year was scheduled to end on June 11, 2021. However, with the changes of the school calendar, DepEd moved it to July 10. This could have affected the teaching-learning process of the last quarter which had shorter number of school days. Although the number of school days was increased, it could have had a contributory impact with regard to the preparation of 4th quarter learning materials, summative tests and other activities such as graduation, accomplishment reports, among others.

The researcher was motivated to conduct this research endeavor as a response to the academic challenges being experienced by the grade 4 DHH learners as presented in tables 1 and 2. This intervention is called *Araling Panlipunan* Filipino Sign Language (AP-FSL) intended to contribute to the limited multimedia learning resources specifically designed for the DHH learners [26]. The general objective of this study is to come up with an intervention that is aimed at the increase of the vocabulary of DHH learners in Filipino-written AP subject.
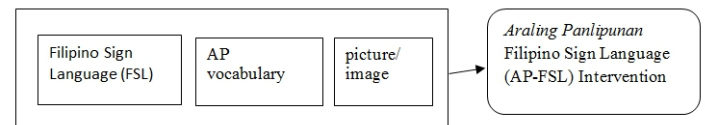
Table 2. Mean percentage scores (MPS) of pre-test and post-test.

Grade Level	No. of Items	No. of Pupils	PRE-TEST MPS	POST-TEST MPS	Difference
4	50	30	9.33	83.47	74.14

MPS Mean Percentage Score

Table 3. Level of AP vocabulary.

Grade 4 Sections	AVERAGE PRETEST RESULTS	*Proficiency Scale	AVERAGE POSTTEST RESULTS	*Proficiency Scale
NARRA	5.82	Frustration Reading Level	42.64	Independent Reading Level
MAHOGANY	4.56	Frustration Reading Level	40.89	Independent Reading Level
YAKAL	3.50	Frustration Reading Level	41.10	Independent Reading Level

*Proficiency Scale was based from the Reading Level Proficiency Rubric of Philippine Informal Reading Inventory (Phil-IRI)

level of language proficiency scaled as follows: 0-15, Frustration Reading Level, which means that the learners found the AP-FSL intervention so difficult that they cannot successfully respond [29]; 16-35, Instructional Reading Level, which means that the learner benefited the most from the teacher-directed instruction in AP vocabularies; and 36-50, Independent Reading Level, which means that the learners could function on their own and the results were almost perfect in terms of reading and comprehension through sign language.

The 50 item AP vocabularies were taken from the Most Essential learning Competency (MELC)-based Self Learning Modules (SLM). AP vocabularies included were the following: *mamamayan, komunidad, bansa, teritoryo, lupain, demokrasya, soberanya, saligang batas, konstitusyon, Pilipinas, arkipelago, kultura, republika, ehekutibo, lehislatibo, kongreso, hudikatura, Luzon, Visayas, Mindanao, La Union, Pangasinan, Nueva Vizcaya, Quirino, Pampanga, Tarlac, Zambales, Bulacan, Cavite, Laguna, Rizal, Quezon, Bicol, Iloilo, Cebu, Samar, Leyte, Zamboanga, globo, mapa, ekwador, Asya, pulo/isla, hayop, ibon, bundok, gulay, pagsasaka, lindol, pagbaha/baha*. Sign language was executed twice. The AP vocabulary appeared first, and followed by manual sign language, fingerspelling, image and another manual sign language. To verify the increase in the pupils' vocabulary in AP, the pre and post-test results were compared. The significant difference of the pre-test and post-test was computed using the dependent t-test. The data was gathered, recorded and interpreted using the Level of Vocabulary Proficiency Form.

Figure 3 depicts the component of the intervention in the form of multimedia learning resource material containing different AP words written in Filipino language, images and sign language. Vocabularies.

The qualitative data collection of this study was done using the AP-FSL Feedback Form was presented to evaluate the overall effectiveness and applicability of the intervention in terms of content, layout and accessibility aspects. It contained a five-point Likert Scale which may be answered by checking under the number that corresponded to the evaluators' responses. The criteria on the said scale were rated as follows: 5-Strongly Agree; 4- Agree; 3 Neutral; 2 Disagree; and 1 Strongly Disagree. The weighted means was interpreted with the same arbitrary scale, viz: 5 Strongly Agree, which means strong affirmation of the APFSL to be used as intervention; 4 Agree, which means affirmation of the APFSL to be used as intervention; 3 Neutral, which means that APFSL may or may not be suitable to be used as intervention and needs more revisions;

2 Disagree, which means negative affirmation of the AP-FSL to be used as intervention; and 1 Strongly Disagree, which means strong negative affirmation of the proposed intervention and the proposed intervention is not suitable for DHH learners. It also contained comments section for a specific feedback and suggestion from the stakeholders. To validate their responses, a 1015-minute, unstructured phone interviews were also applied.

3.3 Data analysis

The data gathered was also analyzed using the following statistical tools:

3.3.1 Mean was used to get the scores of the grade 4 DHH pupils when data are grouped into before and after the AP-FSL intervention.

3.3.2 Paired Sample T-Test was used to compare the results or mean scores from the pre and post-test.

3.3.3 Thematic analysis was applied to come up with specific themes generated from the unstructured interview.

4. Results and Discussion

The findings of a study on enhancing the vocabulary of grade 4 DHH learners through AP-FSL intervention is presented in accordance with the aforementioned research questions as follows:

4.1 In order to measure the level of AP vocabulary of the grade 4 learners before and after completing the intervention program, data gathered were carefully recorded, tabulated, and analyzed to see the difference using a paired sample t-test. The data is presented in tabular presentations for easy identification of the variances. Table 4 shows the results of the pre-test and post-test of the 30 participants in the 50-item test conducted by the researcher before and after the utilization of the AP-FSL intervention.

It revealed pre and post-test results of 9.33 and 83.47 MPS, respectively. It clearly reflects in Table 2 that there was a remarkable increase in the MPS of pre-test of the participants after the utilization of the APFSL intervention with 74.14 difference. This is a significant intimation that the utilization of AP-FSL is an effective and potent multimedia material intervention in increasing the AP vocabulary of the DHH learners.

4.1.1 Table 3 shows the overall level of AP vocabulary obtained by learners of grade 4 classified in three sections.

The pre-test results of the three grade 4 sections, namely, Narra (5.82), Mahogany (4.56) and Yakal (3.5), fell under the frustration reading level. This means that the learners find

Table 4. T-test result on finding the significant difference in the means of the Grade 4 pupils before and after the utilization of the AP-FSL intervention.

Variables Compared	DF	MPS	Computed t-value	Critical t -value	Decision	Impression @ 0.05 Level
Pre-Test (X1)	29	9.33	80.19	1.70	Reject H$_o$	Significant
Post-Test (X2)		83.47				

MPS Mean Percentage Score

Table 5. The overall perceptions and opinions of the stakeholders in the implementation of the AP-FSL intervention.

Positive Feedback and Things Appreciated from the AP-FSL Intervention	Challenges and Suggestions to Improve the AP-FSL Intervention
• The content of the AP-FSL is very applicable. It provides appropriate accommodation to It enjoyment through the use of multimedia	• *Some signs utilized need to be enhanced for proper FSL recognition (Mindanao, La Union, Cavite, Samar, Leyte, Asya, lindol)*
• Very accessible. Big help for them to recognize the words or what their teacher teaches through the use of multimedia.	• Accessibility to computer may vary depending of the current memory, features- some format may not be opened to some laptop models... you can save it in multiple formats like mp4, mov, wmv, etc
• Easy to understand layout. Easy to understand, convenient learning, students finding it interesting, time-saving, and effective	• AP vocabularies used maybe accompanied with short meaning to understand by the deaf
• The delivery and presentation is impressive	• Unstable internet connection affects the stakeholders access to the multimedia intervention

the AP vocabularies so difficult that they cannot successfully respond. The average post-test results revealed positive impact of the AP-FSL intervention which fall under the independent reading level. Narra obtained the highest post-test result at 42.64; followed by Yakal, 41.10; and Mahogany, 40.89. This means that the grade 4 learners can function on their own with excellent comprehension using sign language after the intervention [29].

4.2 Table 4 shows the result of the t-test in finding the significant difference in the pre-test and post-test results.

Based from the t-value of 80.19 and the critical t-value at 1.70, the researcher rejected the null hypothesis, which is significant at 0.05 level. This implies that there was a very significant improvement in the AP vocabulary of grade 4 pupils because of the remarkable increased of the mean after the implementation of the intervention.

4.3 Survey results or rating of the stakeholders to the AP-FSL intervention was at 4.61 with an interpretation of Strongly Agree which implies that AP-FSL is strongly recommended to be used as intervention to help the grade 4 pupils increase their AP vocabularies which are written in Filipino language. Table 5 summarizes the overall perceptions, challenges, opinions, and specific suggestions in relation to the implementation of the AP-FSL intervention. It contains the qualitative data gathered through interview and survey questionnaires.

Three themes emerged from this research on the overall perceptions, challenges, opinions, and specific suggestions in relation to the implementation of the AP-FSL intervention. The themes included Content Layout, Accessible Technology, and Perceived Challenges.

4.3.1 Content and Layout. Contents were derived from the Self Learning Modules (SLMs) written in Filipino. Words included are often encountered from first to fourth quarter. The interviewed learner, parent, teacher, and Deaf community representative described their experience of using AP-FSL in positive terms. AP-FSL was seen as effective, easy to understand and enjoyable learning resource material. The stakeholders also observed that the layout was simple and concise. Furthermore, it was evident that the pupils sign as they read the content of the AP-FSL just like reading the words aloud. This was a good indication of learning because as mentioned in the related studies, to be able to experience a good vocabulary and reading

comprehension, the pupil must be able to identify words easily [30]. Clearly, the interventions' features fit the learning characteristics of the learners with hearing loss by allowing them to enhance their AP vocabulary in an enjoyable manner [31]. A Deaf community representative suggested sign language modifications to some AP vocabulary (e.g., *Mindanao, La Union, Cavite, Samar, Leyte, Asya, lindol*) in accord with the Deaf community's standards. A teacher suggested that short meaning of the word may be included in the slides. This is very crucial observation to deepen the DHH learners' understanding of the given AP vocabulary. However, mastering basic AP vocabulary is a requisite before/proceeding to the more complex phrases written in Filipino

4.3.2 Accessible Technology. The stakeholders believed that the AP-FSL intervention is very accessible, considering that it can be accessed using any iOS or Android device. DHH learners can access it during their free and convenient time. Hence, they can watch and navigate it several times, without any assistance, until they memorize the vocabularies presented. Considering that this is a multimedia with sign language interpretation, DHH learners find it interesting and engaging. They copy the signs they see from the video which also contains AP vocabulary and picture.

4.3.3 Perceived Challenges. The interviewed teacher shared her concern about the internet connection challenges. In the Philippines, 31% percent of Filipino families with members studying through online distance learning have weak internet connection [32]. The level of internet connectivity also affects the quality of the multimedia intervention. In addition, some gadgets have limited capacity to view multimedia depending on the format available. The AP-FSL is in an MP4 format which can be viewed in a typical telecommunication device like computer, cellular phone, tablet, among others.

5. Summary and Conclusions

The general purpose of this study is to develop an intervention called AP-FSL and address the challenges experienced by the grade 4 DHH learners in Filipino-written AP vocabularies. To summarize, the results of the study were discussed in accordance with the research questions as follows:

5.1 The level of AP vocabulary of the grade 4 DHH learners

before the intervention was at Frustration Reading Level with 9.33 mean percentage score (MPS). After the AP-FSL intervention, the learners got an MPS of 83.47%, which shows a remarkable increase with 74.14 difference. This is a significant intimation that the utilization of AP-FSL is an effective and potent multimedia material intervention in increasing the AP vocabulary of the DHH learners. The average posttest results revealed positive impact of the AP-FSL intervention which fall under the Independent Reading Level which means that the grade 4 learners function on their own with excellent comprehension after the intervention;

5.2 The result of the AP-FSL intervention implied that there was a very significant improvement in the AP vocabulary of grade 4 pupils because of the remarkable increased of the weighted mean. The overall impression or rating of the stakeholders to the AP-FSL intervention was 4.61 with an interpretation of Strongly Agree in favor of the said intervention. It is also strongly recommended to be used as additional learning resource materials in enhancing the literacy of DHH learners in written Filipino language.

5.3 Summary of suggestions, overall perceptions, challenges and opinions of the different stakeholders in relation to the implementation of the AP-FSL intervention were also recorded for its further enhancement. Among the suggestions were: (a) utilization of appropriate sign language for proper FSL recognition (Mindanao, La Union, Cavite, Samar, Leyte, Asya, lindol); (b) AP vocabularies maybe accompanied with short meaning to understand by the Deaf learners; (c) accessibility issue of the laptop features; and (d) issue on internet connection.

5.4 In conclusion, AP-FSL intervention has a very significant impact in improving the literacy skills of grade 4 DHH learners. Three themes emerged (content layout, accessible technology, and perceived challenges) from this research on the overall perceptions, challenges, opinions and specific suggestions in relation to the implementation of the AP-FSL intervention.

5.4.1 The stakeholders' overall impression of the developed intervention, in terms of its effectiveness and applicability, was strongly agree, which showed a high level of acceptability for it to be used as an online learning resource material to improve their vocabularies in Araling Panlipunan which are written in Filipino. This study may also serve as a benchmark for future research related to the field of deaf and hard-of-hearing education in the Philippines. Moreover, considering that the stakeholders gave the rating of "strongly agree", this indicated that an intervention is necessary to achieve an increase to AP vocabularies of DHH learners. More related research studies may be undertaken to address the perceived limitations of this study.

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Developing a structural equation model: Case study of Thai port developing

Thanyaphat Muangpan[1] and Ronnakrit Settadalee[1,*]

[1] **Faculty of Logistics, Burapha University, Thailand**

Abstract

The Covid-19 pandemic substantially affects the global tourism industry. The cruise travel business has been one of the most important sources of national income. Therefore, the first need is to improve the cruise ports. This research aims to analyse and develop the structural model of the relationships, dimensions as well as indicators of the cruise port development. The survey research is used in data collection with 342 samples from the Thai tourism business association as well as from the cruise and yacht professionals' association. Three hypotheses drive the indicators to set a relationship among three dimensions that include the cruise tourism factor, the cruise ship characteristics, and the cruise port dimension. Structural equation modelling (SEM) was used to develop this model using the PLS method. The findings revealed that the development of the Thai cruise port model offers the relationship of three dimensions and sixty-nine indicators for improving Thai cruise ports. These results showed a path analysis and measurement model confirming the indicators among these dimensions. The results were also conceptualized into a guideline for how to implement a policy for the cruise port development to support the tourism industry and national economics.

Keywords: cruise port, cruise ship, cruise tourism

1. Introduction

International travel is intended for various reasons including recreation, exploration, business, and discovery. Mass transportation is much more different from a century ago. Nowadays, technology and innovation have been enhanced to support our everyday lives. The incomes from the tourism business are equal to petroleum exports, automobile, or electronic industries. Consequently, tourism is a major source of income among developing countries [1]. International tourist arrivals (overnight visitors) grew around 4% from January to March 2019, compared to the same period of the previous year, and just 6% below the average growth compared to the past couple of years. Transportation takes the travellers from point to point and there were more functions for the itinerary [2]. The road trip is the most used mode of transportation, followed by rail, air, and maritime transportations in respective order. The tourism industry relies on the quality of transportation to serve travellers to their itineraries. According to the report from the Division of Economic Tourism and Sports, there were 39 million international travellers to Thailand in 2019. It cost around 1.9 billion baht as the country's national income [3]. The inbound - outbound travellers via Suvarnabhumi Airport total more than 100,000 persons, while more than 35,000 people per day travel through Phuket Airport. Maritime transportation means transport where goods (or people) are transported via sea routes. Laem Chabang Port has been promoted by the Government of Thailand to be the national main port, replacing the Bangkok Port where the freight containers were limited not to exceed 1.0 million TEU since 1996 [4].

*Corresponding author; email: ronnakrit@go.buu.ac.th

A port is also specifically designed for a cargo operation. Because if a ship is unable to load and discharge the goods, there is no income gained. Therefore, both ship and port must operate together. Furthermore, a port must be designed appropriately for a specific type of cargo or cruise ship. Right now, there are three main Thai cruise ports–Bangkok, Laem Chabang, and Phuket [5]. The Government of Thailand has developed the strategy to promote cruise tourism for 2018 – 2027 to push Thailand as the centre of ASEAN cruise tourism, covering the development of infrastructure at the main ports, Bangkok Port and Laem Chabang Port, and supporting the anchoring points including Koh Samui Pier and the piers linking the islands of tourist destinations. The infrastructure development at the EEC project area will further improve Thailand's East Sea to be more convenient transportation and to connect with local tourist destinations as well as other neighbouring nations in the CLMVT region. The cruise industry was once especially driven by the private sector, even though it would have elevated the Thailand tourism economy and generated more employment. The exploration of factors associated with a cruise port improvement would result in the strategic plan for the development of the Thailand cruise ports.

2. Theoretical Framework

The cruise industry is of greater value with its continuous growth. As cruise tourism is delivered to every port of call and hinterland [6], when analysing the factors for cruise line port selections such as Phuket port, cruise passenger traffic 460,963 persons, an annual growth rate of 12%.

As McCalla [7] suggested, ships had specific ports for cargo,

Table 1. Thai Cruise Port Dimension.

Thai Cruise Port dimensions
Cruise port (Cp)
Boarding Point (Cp 1) Drop off Point (Cp 2) Water width for Ship length < 250 m. (Cp 3) Water width for ship length 250 – 400 m. (Cp 4) Water width for ship length > 400 m. (Cp 5) Channel Depth > 10 m. (Cp 6) Channel Depth 10 – 15 m (Cp 7) Channel Depth 15 – 20 m.(Cp8)
Ship's Length < 175 m. (Cp 9) Ship's Length 175 - 250 m. (Cp 10) Ship's Length > 250 m. (Cp 11)
Port location from Public Transportation < 1 km. (Cp 12) Port location from Public Transportation 1 – 3 km. (Cp 13)
Port location from Public Transportation > 3 km. (Cp 14) Berth alongside 1 ship (Cp 15) Berth alongside 2 ships (Cp 16)
Berth alongside > 2 ships (Cp 17) Passenger waiting for area (Cp 18) Baggage Transportation System (Cp 19)
Tariff rate < 18,000 Baht/day (Cp 20) Tariff rate 18,000 – 27,000 Baht/day (Cp 21) Port Connection System (Cp 22)
Vehicle Connection System (Cp 23) Boat System Connecting (Cp 24) Weapon Inspection System (Cp 25)
Additional measures for new incidence diseases (Cp 26) Port security hierarchy (Cp 27) Operation process (Cp 28)
Supporting Point (Cp 29) Port link to Airport < 0.5 hrs (Cp 30) Port link to Airport 0.5 - 1.5 hrs (Cp 31) Port link to Airport > 1.5 hrs (Cp 32) Port link to Rail Transportation < 0.5 hrs (Cp 33) Port link to Rail Transportation 0.5 1.5 hrs (Cp 34)
Port link to Rail Transportation > 1.5 hrs (Cp 35) Port link to Road Public Transportation < 0.5 hrs (Cp 36)
Port link to Road Public Transportation 0.5 - 1.5 hrs (Cp 37) Port link to Road Public Transportation > 1.5 hrs (Cp 38)
Measures to Prevent Oil Pollution. (Cp 39) Measures to control pollution from toxic liquids in total volume (Cp 40)
Measures to prevent pollution from hazardous substances transported by sea in package form (Cp 41)
Measures to prevent pollution caused by ship sewage (Cp 42) Measures to control garbage in port (Cp 43)
Measures to prevent air pollution from ships (Cp 44) Measures to deal with dust problems (Cp 45)
Cruise tourism (Ct)
Contemporary & Premium (3 – 7 Night) (Ct 1) Upscale (+Superior dining etc.) (Ct 2) Luxury (12 Nights +) (Ct 3)
Expedition (high standard) (Ct 4) Port to historical attraction < 0.5 hrs (Ct 5) Port to historical attraction 0.5 - 2.0 hrs (Ct 6)
Port to historical attraction > 2.0 hrs (Ct 7) Port to Natural attraction < 0.5 hrs (Ct 8) Port to Natural attraction 0.5 - 2.0 hrs (Ct 9)
Port to Natural attraction > 2.0 hrs (Ct 10) Convenience, safety, public transportation (Ct 11) Tourism Safety (Ct 12)
Tour Capabilities (Ct 13) Port to Department Store/Duty free Shop < 0.5 hrs. (Ct 14)
Port to Department Store/Duty free Shop 0.52.0 hrs. (Ct 15) Port to Department Store/Duty free Shop > 2.0 hrs. (Ct 16)
Port to Hotel < 0.5 hrs. (Ct 17) Port to Hotel 0.52.0 hrs. (Ct 18) Port to Hotel > 2.0 hrs. (Ct 19)
Cruise ship characteristics (Cs)
Mega Ship (number of passengers 3,500 or more) (Cs 1) Large Ship (Number of passengers from 2,0003,500 (Cs 2)
Midsize Ship (Number of passengers from 700 to 2,000 passengers) (Cs 3)
Small Ship (Number of passengers ranging from less than 750) (Cs 4)
Expedition Ship (Number of passengers ranging from less than 100 to 300 passengers) (Cs 5)

though cruise ships had itineraries covering the entire world. There were three types of cruise portshome port, port of call, and hybrid port. A cruise port should be improved by both cruise lines as well as the government. Many factors were used for making decisions to create and execute acts. Factors associated with port development factors are modified by the port site and port situation. The cruise ports were chosen by cruise lines. [7] The first factor for deciding to be a cruise port was tourist attractions. The second was facilities to respond to tourists' needs. The Fuzzy-AHP method was used and four categoriesincluding, cruise terminal facility, natural environment of the hinterland, tourism attractions, and connectivity and agility at Singapore and Hong Kong cruise portswere analysed. Hong Kong had concentrated on the development of the modern cruise terminal with the prospect of Hong Kong being a major cruise hub. Thailand's GDP main mainly comes from the tourism industry. Cruise travellers almost always have high purchasing power and usually connect to the hinterland, making employment in the business sector [8]. They studied the factors for developing Thailand Cruise Port during the Covid-19 pandemic. The sampling was done by cruise port users, including ATTA: Association of Thai Travel Agents, Cruise Agents, and CAT: Cruise Ship Professional Association. The cruise port potential range was measured by port site, port situation, and ship characteristics. The potential range average was a result of users identifying the level of Thai cruise ports at a middle to almost good scale. Some factors revealed recommendations for the policymakers to adjust the strategy for promoting tourism. The results led to strategic planning for the development of Thai
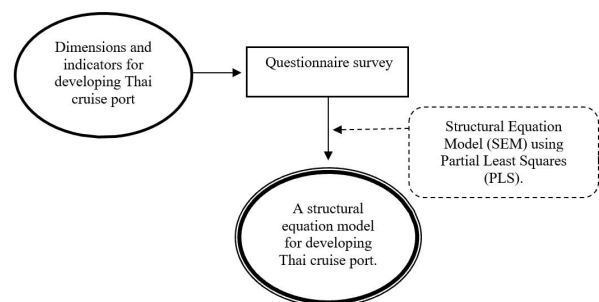
Figure 1: The methodological design

cruise ports for all parties.

3. Methodology

This research methodology was designed as shown in Figure 1. The past research was used the data of factors for developing Thai cruise ports which were found in the previous article and reviewed literature. The framework was developed from documentary research using content analysis. This research used survey research that collected all data by selective sampling. The sampling method was non-probability sampling, in which the stakeholders in the processing of the Thai cruise port were selected using purposive sampling. A total of 342 samples consisted of 300 samples from the Thai Tourism Business Association and 42 samples from the cruise professionals/yacht professionals associations. A 5-scale rating questionnaire was
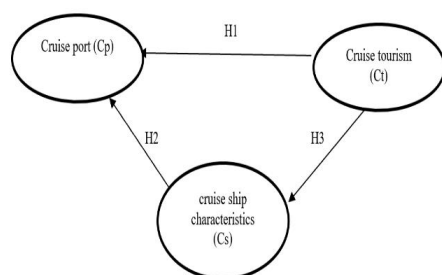
Figure 2: Framework for developing Thai cruise port

Table 2. Results of hypothesis testing.

Path	Path coefficient	t-test	p-value	Results
H1: Ct to Cp	0.871	7.771***	0.000	support
H2: Cs to Cp	0.859	32.206***	0.000	support
H3: Ct to Cs	0.013	0.109	0.913	non-support

p-value* < 0.1, p-value** < 0.05, p-value*** < 0.01

Table 3. Reliability and validity of Structural equation modelling.

Dimensions	CR	AVE	Cronbachs alpha
Cp	0.977	0.507	0.975
Ct	0.942	0.475	0.933
Cs	0.836	0.508	0.775
Average	0.9183	0.4966	0.8943

*GoF is 0.5152

applied to collect data for finding the opinions of respondents on the current situation and the important factors for Thai cruise ports. Three main factors (69 sub-factors were demonstrated in Thai cruise port dimensions) of the questionnaire were presented, including the cruise port factor, cruise ship characteristics factor, and cruise tourism factor.

In this study, there were three hypotheses which drove the indicators to set the relationship among the dimensions as follows:

H1: The cruise port was positively influenced by the cruise tourism dimension.

H2: The cruise port was positively influenced by the cruise ship characteristics dimension.

H3: The cruise ship characteristics were positively influenced by the cruise tourism dimension.

Structural equation modelling was applied to develop the model using the PLS method. This resulted in the path model and measurement model for testing the cause and effect of the relationships among factors and presenting estimation measurements between dimensions and indicators [9]. The first result of this model was to offer a reliable valid measure of the dimensions and the relationship among factors to the path model. For the second result, the model fitted in the investigation of structural equation modelling proposed the path coefficients of the factors and indicators loading.

4. Findings

The structural model results for developing Thai cruise port were represented in Figure 3, while the average of R? presenting was 0.755, indicating this model was highly significant. The cross-loadings and the variability of factors were clarified by indicators that were shown that most factors and their indicators were above 0.7. The structural equations were shown as follows:

$Cp = 0.871 \, Ct + 0.013 Cs$; $R^2 = 0.779$,

$Cs = Ct$; $R^2 = 0.859$

Cp: Cruise port dimension, Ct: Cruise tourism dimension, Cs: cruise ship characteristics dimension

The results of hypothesis testing were presented in Table 2 showing the path coefficient, t-test, and p-value. These results showed that using PLS-SEM analysis in three hypothesis paths, two hypothesis paths were supported, while one hypothesis path remained unsubstantiated. Firstly, the direct path between cruise tourism (Ct) and cruise port (Cp) was significantly supported (p-value = 0.000). Secondly, the direct path between

cruise ship characteristics (Cs) and cruise port (Cp) was significantly supported (p-value = 0.000). Thirdly, the direct path between cruise tourism (Ct) and cruise ship characteristics (Cs) was not significantly supported (p-value = 0.913). It meant that the cruise port (Cp) was positively influenced by cruise tourism (Ct) with a path coefficient of 0.871. The cruise port (Cp) was positively influenced by the cruise ship characteristics (Cs) with a path coefficient of 0.859. Another hypothesis path which was not supported was the cruise ship characteristics (Cs). It was positively influenced by cruise tourism (Ct) and found that the path coefficient was 0.013.

The reliability and validity of structural equation modelling were presented by Composite Reliability (CR), Average Variance Extracted (AVE), and Cronbach's alpha, as shown in Table 3. These results were extracted to qualify the model measurement and Goodness of Fit (GoF) at 0.5152, indicating the data fitted the model at an acceptable level. The CR average was 0.9183 which was above 0.7 which represented an acceptable value. The AVE average was 0.4966 which had been calculated to be 0.5 for acceptance. The average of Cronbach's alpha was 0.8943, more than 0.7 which is widely accepted as the cut-point [9]. From these results, the factors were well validated as the indicators, and this model was fitted.

5. Results and Discussion

The cruise industry has the characteristic capabilities to relocate from region to region and respond to the tourism economy. A cruise port has multi-functions and is established by several factors. Thailand cruise ports are divided into three parts. Thai ports have been provided by the Government of Thailand with both the infrastructure and transportation systems. The relationships between the three factors, cruise tourism (Ct), cruise port (Cp) and good ship characteristics (Cs) were elucidated in detail below.

The first factor was cruise tourism (Ct). Thailand had various attractions supporting business travel. Both natural and historical attractions impressed travellers around the world. The Thai hospitality business sector also contributed to this factor enormously. Among the Ct factor, the associated indicators included port to a historical attraction for 0.5   2.0 hrs$_{(Ct6)}$, expedition (high standard) $_{(Ct4)}$, port to a natural attraction for 0.5 – 2.0 hrs $_{(Ct9)}$, upscale (+ superior dining etc.) $_{(Ct2)}$, luxury
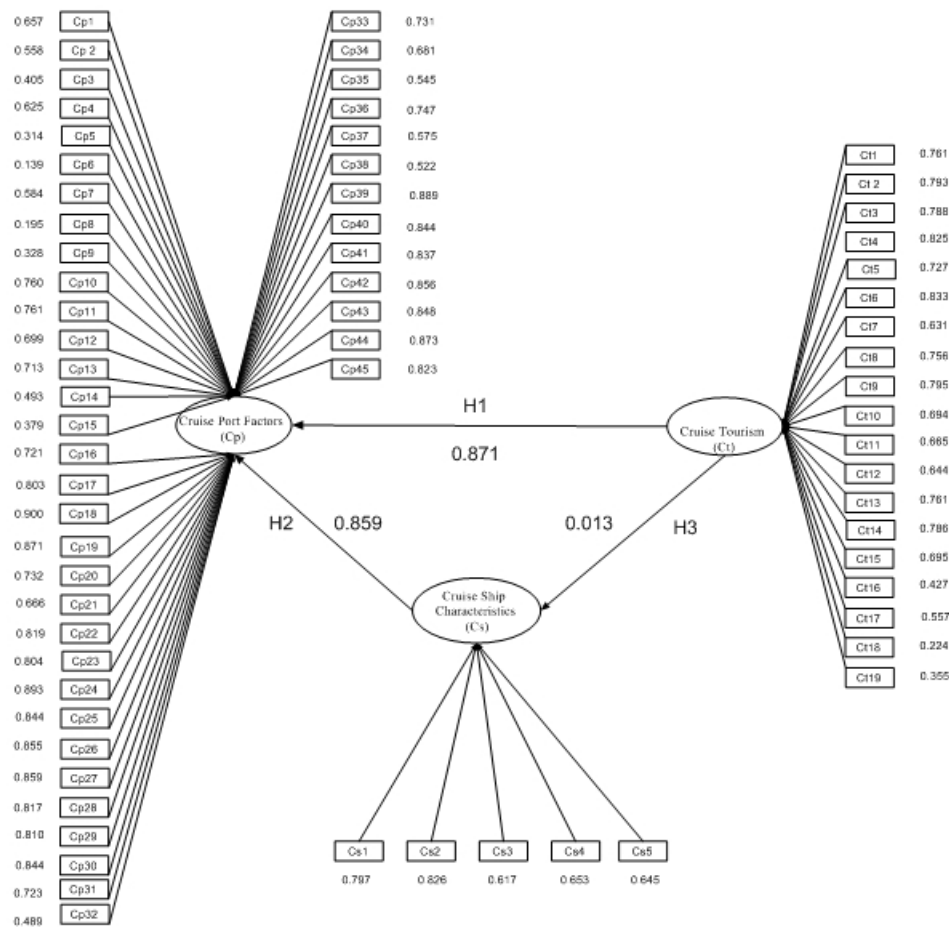
Figure 3: The Structural equation modelling for developing Thai cruise ports.

(12 nights +) $_{(Ct3)}$, port to a department store or a duty free shop < 0.5 hrs $_{(Ct14)}$, tourism capabilities $_{(Ct13)}$, contemporary and premium (3 – 7 Night) $_{(Ct1)}$, and port to a natural attraction for < 0.5 hrs $_{(Ct8)}$. The results also revealed that the time spent in a historical attraction for 0.5 – 2.0 hours was the proper period. Furthermore, the opportunity to support Thai cruise tourism was department stores and duty-free shops situated in the proximity of a port.

Secondly, for the cruise port (Cp), we had suggestions that ports should be subsidized by the Government. A port needed a substantial amount of budget to establish. Therefore, a Thai cruise port adapted from a port for cargo ships did not completely serve the cruise tourism objectives. The significant indicators supporting the development of a cruise port included the ship's length of 175 – 250 m $_{(Cp10)}$, the ship's length of > 250 m $_{(Cp11)}$, the berth alongside 2 ships $_{(Cp16)}$, the berth alongside > 2 ships $_{(Cp17)}$, the passenger waiting area $_{(Cp18)}$, the baggage transportation system $_{(Cp19)}$, the tariff rate < 18, 000 baht per day $_{(Cp20)}$, the port connection system $_{(Cp22)}$, the vehicle connection system $_{(Cp23)}$, the boat system connecting $_{(Cp24)}$, the weapon inspection system $_{(Cp25)}$, the additional measures for infectious diseases $_{(Cp26)}$, the port security hierarchy $_{(Cp27)}$, the operation process $_{(Cp28)}$, the supporting point $_{(Cp29)}$, the port link to an airport of < 0.5 hrs $_{(Cp30)}$, the port link to an airport of 0.5 - 1.5 hrs $_{(Cp31)}$, the port link to an airport of rail transportation < 0.5 hrs $_{(Cp33)}$, the port link to a road public transportation

< 0.5 hrs $_{(Cp36)}$, the measures to prevent oil pollution. $_{(Cp39)}$, the measures to control pollution from toxic liquids in total volume $_{(Cp40)}$, the measures to prevent pollution from hazardous substances transported by sea in package form $_{(Cp41)}$, the measures to prevent pollution caused by ship sewage $_{(Cp42)}$, the measures to control garbage in port $_{(Cp43)}$, the measures to prevent air pollution from ships $_{(Cp44)}$, and the measures to deal with dust problems $_{(Cp45)}$.

Thirdly, the cruise ship characteristics (Cs) were defined as the specific characteristics of a cruise ship suitable for a Thai port. A cruise ship is usually tailored by the objectives of the journey and purchasing power. Moreover, it is also related to the length of an itinerary period. The study demonstrated that the Thai cruise port should be adjusted for this purpose. In respective order, the supporting indicators included large ship $_{(Cs2)}$, mega-ship $_{(Cs1)}$, small ship $_{(Cs4)}$, expedition ship $_{(Cs5)}$, and midsize ship $_{(Cs3)}$. The relationship between cruise tourism and cruise port was as significant as port facilities for passengers. To promote cruise tourism, the authorities should provide the proper itineraries and support emergency plans during a trip. Moreover, the port tariffs and transportation fees should be fined corresponding to the port performance as well.

The main objective of cruise tourism is to provide itineraries suitable for a group of passengers' interests and purchasing power. We showed that it not only influenced the decision to choose ship types but also optimised budgets more efficiently.

The cruise ship characteristics and cruise pots should have supported each other. A port should be designed to match a ship type. Therefore, the port authorities should provide facilities to serve all ship sizes and respond to every condition. We demonstrated that the cruise ships have less effect on a cruise port. The parties concerned in cruise tourism would be to launch promotion campaigns and onshore itineraries to call cruise ships and passengers made more spending with activities.

This study aimed to reveal the opportunities for development for the policymakers to adjust and develop a cruise port. We presented the path models representing how the cruise tourism and cruise ship characteristics dimensions affected the cruise port dimensions. In conclusion, we suggested that the authorities should consider our supporting indicators to create cruise ports suitable for serving cruise tourism and the present-day cruise ship characteristics and promoting the sustainability of the tourism business.

6. Conclusion and Recommendations

Thai Cruise Tourism is a promisingly prominent part of the maritime tourism economy. It can drive business circles and promote more employment. This study developed the structural model of the cruise port development using the survey research called PLS-SEM. This model found that cruise tourism and cruise ship characteristics are the main factors guiding how to prepare a development plan for the Thai cruise ports. As a result of the fact that cruise tourism contributes to the cruise ship characteristics, the Thai Government should establish cruise ports with the potential to serve all cruise ship types. The authorities should concern and integrate all these associated indicators to

formulate a strategic plan for raising the standard and quality.

Finally, both the government and the business owners must cooperate in creating and designing travel itineraries and providing the facilities to promote the cruise travel industry. Our upcoming future research will shed light on how to develop a sustainability plan for improving the cruise ports by incorporating the relating factors like environment and social factors into the economic factors.

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Travelers, merchants, and foreigners appeared in facial stucco sculptures in Dvaravati humans in Nakhon Pathom Province

Supitchar Jindawattanaphum[1,*]

[1] **Social Studies Program, Faculty of Humanities and Social Sciences, Nakhon Pathom Rajabhat University, Thailand**

Abstract

This research article is part of the research on innovation in the face of Dvaravati people, a case study of stucco sculptures and antiques in the Dvaravati period by Adobe Photoshop. Nakhon Pathom, originally called 'Nakhon Phra Krit,' was an ancient city which has the largest city plan of all ancient cities in the Dvaravati era. It was also a significant port situated in the western of Chao Phraya River, between Mae Klong River and Tha Chin River. There was a great number of antique evidence discovered. This also showed the evolution of the growth of Nakhon Pathom, the city of significant geographical landmarks and locations, which developed to be a large city since the 12th-century B.E.. This ancient city was a port city that had marine transportation connecting local communities such as Kamphaeng Saen, Phong Tuk, and Khu Bua, as well as communities not far from coastlines. Furthermore, there were also river pathways shipping from the Gulf of Thailand, through Pak Nam to Nakhon Pathom Ancient City. There was a discovery of Phanom Surin shipwreck, around a shrimp pond in Phanthai Norasing Sub-district of Samut Sakhon Province which was around 8 kilometers from the coastline and not far from Nakhon Pathom. The shipwreck was an ancient Arab boat shipping goods such as ivories, betel fruits, coconuts, rice seeds, antlers, and Tang dynasty porcelains. It could be assumed a ship of merchants which was consistent with the discovery of antique evidence in Nakhon Pathom Province such as beads, ancient coins, seals, and Tang dynasty porcelains. This evidence could ascertain the contact of merchants between this city and the Middle East, India, and China. Furthermore, from the antique study of facial stucco sculptures of humans in the Dvaravati period, these sculptures were created to decorate religious sites. A great number of antique evidence found at Wat Phra Prathon Chedi, Chulprathon Pagoda, and Wat Phra Pathom Chedi showed that those facial stucco sculptures had various facial characteristics, i.e., facial appearances, turbans, usage of facial embroideries, which were different from local Dvaravati citizens. These sculptures evidence the traveling of travelers, merchants, and foreigners who focused on seeking fortunes, trading, and propagating religions.

Keywords: traveler, merchant, foreigner, facial stucco sculpture of Dvaravati people

1. Introduction

Nakhon Pathom is an ancient city in the Dvaravati era which featured a huge rounded corner rectangle of 2 kilometers in width and 3.6 kilometers in length. Without the embankment, there were canals around the city. In the past, Nakhon Pathom was the Dvaravati city that had the biggest canal with an area of 3,809 rai. There was Bang Kaeo Canal running through the city and Phra Prathon Canal in the middle of the city. The size of the city connected the northern and southern canals together while the western side, out of the city, was the location of community and important historic sites. Nakhon Chai Si is the largest ancient city in Thailand, approximately 36,000 × 2,000 meters or about 7 square kilometers, that has a network of ditches and canals connecting inside and outside of the city. There are many religious places both within and outside the city; for instance, Phra Prathom Chedi, Wat Phra Meru archaeological site, and some religious places near Bang Kaeo Canal such as Wat Phra Ngam and Wat Huai Chorakhe, etc. While in the south of Nakhon Pathom Ancient City, it was previously discovered the embankment parallel with the canal dug up in the south, called Khlong Thanon Khat (Srisak Wanliphodom, October-

December 2015: 25) and Bang Kaeo - Bang Khaem River. This was the main transportation route flowing into the sea, assuming that the former coastline was not far from the city, especially at Ban Don Yai Hom (Thiva Supajanya and Pongsri Vanasin 1982: 2 5; Tri Amatayakul 1949: 54 64).

Based on the geography over a thousand years ago, Nakhon Pathom was located near the seaside of the ancient Gulf of Thailand. When sailors and merchants from abroad set on dock to rest and ship the goods, they spread beliefs and cultures, especially the Indians who disseminated Buddhism into Suvarnabhumi since 300 BC. The natives accepted their influences and beliefs from time to time, then developed and inherited prosperity from the eleventh century to the sixteenth century. During this period, many worships and Buddhist religious places were built called Dvaravati Art. At present, there are Dvaravati antiques and archaeological sites found in Nakhon Chai Si or Nakhon Pathom City, which are important evidence of being a seaport state in the Dvaravati period. From the study, there is a greater number of stucco sculptures of human faces decorated many religious places at various archaeological sites both within and outside the city than in other cities in the same period. It was found that the number of those faces was different from natives' faces. There were the faces of outlanders and

*Corresponding author; email: supitchra59@yahoo.co.th

foreigners which were assumed that those people have traveled to Nakhon Pathom Ancient City for various purposes. It can be said that Nakhon Pathom has been the ancient port city over a thousand year as seen in the ancient map showing that Nakhon Pathom is the city near the sea.

2. Objectives

1. To study stucco sculptures of people in Dvaravati era found in Nakhon Pathom

2. To compare the face of Dvaravati people and foreigners who traveled in Nakhon Pathom during that period

3. Research Hypothesis

1. Stucco sculptures of people in Dvaravati period found in Nakhon Pathom can be studied as the important port city in Dvaravati period.

2. Stucco sculptures of people in Dvaravati period found in Nakhon Pathom has featured the face of Dvaravati people and the face of foreigners different from those of Dvaravati people.

4. Research Scope

In this research, the researcher has determined the scope of research by hypothesizing the port city of Nakhon Pathom Ancient City in the Dvaravati Period. 150 pieces of stucco sculptures of Dvaravati people's face found in Nakhon Pathom were studied, then the complete and less damaged pieces were selected. Finally, there were 95 pieces to study.

5. Methodology

The research about travelers, merchants, and foreigners appearing in facial stucco sculptures of Dvaravati humans in Nakhon Pathom is the study to analyze the face that found in Nakhon Pathom Ancient City. More than 150 pieces of sculpture were chosen and 95 pieces were found with completely clear face. From the analysis of the structure of face that looks like foreigner, 15 pieces were found as details described below.

5.1 To study Nakhon Pathom ancient port city, the primary and secondary documental evidences were analyzed. It was found that Nakhon Pathom has developed the prosperity and it is the archaeological site reflecting the settlement during prehistoric period around 2,000 3,000 years ago. The archaeological sites were found at Bo Sai Sub-district in Don Tum District and at Huai Khwang sub-district in Kamphaeng Saen District (The Fine Arts Department, 2005: 22-39), including Khok Plup Community in Pho Hak Sub-district, Bang Phae District, Ratchaburi Province. It evidenced that many people had lived in those areas for thousands of years. Later, the community developed into the country and traded with foreign countries. With the dominant feature of Nakhon Pathom Ancient City that did not have the embankment, it was different from other Dvaravati cities that had around 1-2 floor high embankment. Without the embankment, it was beneficial for sailing the junk boat into the city and it was considered as the physical factor to promote Nakhon Pathom ancient city to become one of the important

trading port cities in the Dvaravati period (Phasuk Intrawut, 1999: 101), Nakhon Pathom ancient city was located in a lowland. Therefore, there was water transportation to connect inside communities such as Kamphaeng Saen Community, Phong Tuk Community, Ku Bua Community, etc., and to connect with outside communities with maritime trade since Nakhon Pathom had some inner area that was not far from the coastline. In addition, there was the water pathway for shipping from the Gulf of Thailand to the estuary and Nakhon Pathom Ancient City. As shown in archives of Somdet Krom Phraya Damrong Rajanuphap, dated March 9th, 1932, saying "I try to find out the reason to build Nakhon Pathom Ancient City. Why was it built there? After researching the evidence for more than 30 years, I discovered that when the city was created, it was near the sea because of the excavation of marine engine at Thammasala Sub-district" (The Prince Narisara Nuwattiwong, 1993: 184). There was evidence of the excavation of an ancient shipwreck Phanom-Surin Boat at the shrimp pond in Phanthai Norasing Sub-district, Mueang District, Samut Sakhon Province which was about 8 kilometer far from the coastline and not far from Nakhon Pathom Ancient City. The result of the excavation and the study revealed that Phanom-Surin ancient boat was large with 25 meters in length. The bow of the ship was facing to the south in which the characteristic of Arab boat. There were a wooden keel of 17.65 meters long and two mainmasts. It was found antiques in the boat such as betel fruits, coconuts, ivories, rice seeds, and antlers, as well as Tang dynasty porcelains. It can be assumed that this boat was probably around 14th 15th century (Saritpong Khunsong, 2016: 175 176). As previously mention, there is more clearly evidence of marine trading of Nakhon Pathom Ancient City in harmony with the evidences of antiques found in the ancient Nakhon Pathom such as glass beads, Tang Dynasty porcelains, including a ship-shaped terracotta seals and bricks as well as stucco sculpture with Muslim faces. It also showed the trade contact between travelers and merchants who traveled via ship between the regions from the West (Arab) to the ancient port of Nakhon Pathom City.

As being the port city located in appropriate geography, it has a positive effect on the development and the growth of the country. It can be seen that Nakhon Pathom Ancient City has a big city plan with many religious sites and antiquities in the ancient city plan which are Phra Prathon Chedi and Chula Prathon Chedi. Moreover, outside Nakhon Pathom Ancient City, archaeological sites in the Dvaravati period are founded all over the city, i.e., Phra Pathom Chedi, Wat Phra Meru Archaeological Site, Wat Phra Ngam Archaeological Site, Wat Huai Chorake Archaeological Site, Wat Thammasala Archaeological Site, Noen Phra Archaeological Site (Don Yai Hom), etc. A large number of found ancient artifacts were built with beliefs and faith in Buddhist and Brahman such as the Wheel of Dhamma and crouching deer, many Buddha images, and stucco sculptures of people's faces. Additionally, ancient antiquities in Hindu were found such as sculptures of gods. Besides, there are antiquities found different from other places which presuming that came from foreign trade. There is evidence of trade dealing with the Middle East in the 13th 16th century or over a thousand years ago. In the early Abbasid dynasty which is the golden age of Muslim world in contemporary with

Figure 1: Picture of Phanom Surin Boat and inside the Arab boat that traveled for trading at Samut Sakhon.
Source: https://www.naewna.com/lady/555662

Figure 2: A Ship-shaped terracotta seal at Nakhon Pathom.
Source: http://thainationhistory.blogspot.com/

Dvaravati civilization in the central Thailand and Srivijaya in the south. Most of antiquities were found in the southern port city rather than in the central plain. It can be reflected that the southern port city is the port for big cargo; then, transferring to the central region. However, the discovery of an ancient Arab boat, Phanom Surin, at Samut Sakhon, indicated that Muslim people had also visited the Gulf of Thailand. It can be said that there was trade between the Middle East and Southeast Asia before the arrival of Islam. When Muslims governed the Persian Gulf, the original ancient port city, they needed to trade with the eastern world to meet the golden era of fine arts and goods such as clothes, herbs, medicine, and natural product. This pushed Muslims to travel to the central of Thailand. On the other hand, it was also in pursuit of knowledge referring to the words of the Prophet Muhammad that "seek knowledge even if you have to go as far as China" (Phanthip Thiranet, 2018: 45). The land of Southeast Asia, known to the Arabs as "Bilad Ashahab" is Suwannabhumi or Suvarnabhumi.

5.2 Sample Population of stucco sculptures with foreign faces in the Dvaravati period

A large number of Dvaravati stucco sculptures used for decorating Buddhist places were found in Nakhon Pathom Province during the Dvaravati period. Most of those stucco sculptures are of Dvaravati people with various different faces. The study shows that headdresses of each face can identify the difference of natives in the Dvaravati. The appearance of the face are thick eyebrows, bulging eyes, big nose, thick mouth, short hair with center parting and simple side parting, and long hair with high and low bun. But the face shape different from natives is the face wearing conical pointy hat, long face, high nose, big eyes, wavy hair, curly hair, including headscarf and different headdresses. It can be assumed that those faces are of people with other nationality, not Dvaravati, which most of scholars assumed that they are Arab merchants, called Semitics in the ancient Middle East region. On the other hand, some scholars argued that Semitics did not wear those mentioned hat. People who wear top-hat like the stucco sculptures are Parthain or Parthia or the Arsacid Empire that prospered during 247 years BC 224 AD. Nowadays, it is located in Iran. This conforms to the discovery of Arab coins in Abbasid dynasty from U-Thong Ancient City. This discovery evidences the contact with people from the Middle East since the Dvaravati period, about 1,200 years ago. However, due to the limited number of coins, it is assumed that those coins may not be mediated the exchange or trade but being the souvenir brought with the Middle East merchants who traveled to U-Thong Ancient City during that period (Saritpong Khunsong, 2015).

From the evidence of stucco sculptures found in Nakhon Pathom Province, it can be assumed that about 1,500 years ago there were the merchants from The West such as Arabs, Persians, Greeks, and Romans, as well as traders from the East such as China and India, came to trade in Nakhon Pathom seaport. When those travelers arrived, they took note of the story which has become important evidence for subsequent studies of many ancient Indian literatures such as Ramayana Epic, Jataka epic, Phra Mahachannok, and Milinthaphan. The land named "Suvarnabhumi" means the land of gold, meaning the richness of natural resources in the Southeast.

From the discovery of a ship-shaped terracotta seal, it represents the vehicle of travelers, merchants, and foreigners who traveled into Nakhon Pathom seaport for shipping from the west to the east. The important thing is the "southwest monsoon" between April and September that blows boats from the starting port city in the Persian Gulf, along the coast of South Asia,

Figure 3: Compare stucco sculptures of people resembled with Chinese and Persian faces.
Source: Phrathom Chedi National Museum, Nakhon Pathom

Figure 4: Comparison of the faces of foreign sculptures found in Nakhon Pathom before and after using Photoshop.
Source: Phrathom Chedi National Museum, Nakhon Pathom

passing Sri Lanka to the Malay Peninsula, across the Strait of Malacca. Some boats go further to Java Island or up to the South China Sea to the destination of Chinese port cities with the main products as silks and Chinese wares. On the return, it relies on the northern monsoon wind between October and February in the following year. Sailing through Southeast Asia back and forth, Persian and Arab merchants can buy spices, forest products, including animal products to sell in the West. According to the geography of Nakhon Pathom in a thousand years ago locating near the Gulf of Thailand, the cargo vessels from the West, traveling to the East to the destination of China, traveled along the coast passing various port cities in Southeast Asia. Nakhon Pathom was the port city that travelers and merchants stopped for resting and exchanging goods and culture. It can be seen from archaeological evidence including various antiquities found in the ancient port cities such as Khu Bua Ancient City, Nakhon Pathom Ancient City, and U-Thong Ancient City. They are beads, Roman coins, Roman lamps, seal, etc. With this reason, various ports had the prosperous development. When the merchants had made the successful trade, they had the faith to donate their money to local religious places. The arts arose from the faith were created and represented the journey. Moreover, it evidences that Nakhon Pathom was an important port city in the Dvaravati period.

From the research of stucco sculptures of Dvaravati people's face found in Nakhon Pathom, more than 100 pieces rather made for religious places decoration at Phra Pathon Chedi, Chula Prathon Pagoda, and Phra Pathom Chedi. It was the evidence of Nakhon Pathom as a port city and the journey of

foreigners. Fifteen pieces were found different from the Dvaravati natives. They wore tall hats with headscarf, had big eyes and high nose, and some had wavy hair, which were different from the faces of Dvaravati people who have round face, thick eyebrows, bulging eyes, and thick mouth. With the number of discovered faces, it can be the evidence to assure the importance of Nakhon Pathom as an ancient port city over a thousand years ago where various nationality travelers and merchants came to trade and exchange cultures. This is in harmony with the hypothesis that Nakhon Pathom was the biggest seaport city in the Dvaravati period.

6. Conclusion

According to the data analysis, the result of the research showed that with the geographical characteristic about a thousand years ago, Nakhon Pathom Ancient City is a port city near the coast. Cargo ships of travelers, merchants and foreigners traveled to this region to seek spices and forest products, since this land was plentiful and prosperous. As in the records mentioned about the land of Suvarnabhumi, it was the connection of maritime world trade between the West and the East where traders from the West travel relying on the southwest monsoon to reach the destinations of various port cities of China. However, along the journey, they had to stop shipping at such port city before arriving China for resting, transferring goods, and doing other activities. When the ship docked, the travelers communicated and made a relationship with the natives of each port city, including exchanging goods, spreading religious, culture

and beliefs. It can be assumed that the port cities where they stopped and stayed overnight, the travelers who were fortune-seekers made a wish at local sanctity. If the trade ships had success in traveling, trading, and bringing the prosperity to sailors and merchants, it reflected their faith and confidence in what they made a wish from the local worship in the local port cities. The merchants with the faith donated their money in return and made merit in the important and sacred places where they stopped the boat and made a wish. Therefore, it is not surprising that the ancient port city, Nakhon Pathom, situated the religious places in the city center, i.e., Phra Pathon Chedi, Chula Prathon Chedi, and the pagoda located a bit far from the center named Phra Pathom Chedi. Consequently, there is a discovery of many stucco sculptures of people's faces that assumingly used as the components to decorate the religious places in the Dvaravati period. Thus, those faces varied from the Dvaravati natives who had round face, thick eyebrows, bulging eyes, and thick mouth. If they were an ordinary man, they would not wear accessories, except lead earrings. If they were aristocracy, they usually wore Chada (Thai theatrical crown) or headdresses. Moreover, the foreigners would have specific characteristics of their faces differentiated from the natives in the Dvaravati period, such as wearing a high-shaped hat and headscarf, having big eyes and high nose, and some having wavy hair. It can be assumed that the stucco faces of those foreigners should be important and have the benefaction for the religious places so that the Dvaravati sculptors created their faces to decorate religious places. Additionally, it can be said that those travelers and the rich foreign merchants who succeeded in traveling and trade had the faith in donating money to create a memorial showing that they had been in Nakhon Pathom Ancient Port City. This sort of memorial is passed through a thousand years to the people nowadays and it is the evidence of the arrival of those people to this region.

7. Results and Discussion

This research studied the stucco sculpture of people's face in the Dvaravati period in Nakhon Pathom province. More than 100 pieces of faces were found, 15 pieces having different faces from the natives' faces. The faces with big eyes, high nose, and wavy hair is assumed the Middle East or European traders, while the face with narrow eyes and wearing headscarf might be Chinese merchants. Therefore, it can be seen that Nakhon Pathom is probably the important port city where foreign merchants came to trade in the Dvaravati period. This is corresponding to Worawut Suwannarit who studied the belief and style of Dvaravati stucco sculptures at Ban Khu Bua. He mentioned about the classification of stucco works and utility, and claimed that stucco sculptures were created for decorating the architecture and solving some problem of external form of architecture. Also, Saritpong Khunsong mentioned the international trade in the Dvaravati in the archaeology aspect in Nakhon Pathom and the archaeological excavation in Nakhon Pathom during 2009-2010. It revealed new evidence that could interpret the foreign relationship and trade activities during the Dvaravati period. The results showed that trade contacts in this era were both internal and international with other foreign

communities far away, especially with the prosperous Srivijaya Kingdom around Sumatra Island of Indonesia, and Malay Peninsula in Thailand and Malaysia.

8. Recommendation

Recommendation from further research, the pieces of stucco sculptures of Dvaravati people's faces that were found in other archaeological sites in the Dvaravati period such as U-Thong Ancient City, Khu Bua Ancient City, Thung Setthi Ancient City, Khok Maiden Ancient City, and Fa Daet Song Yang Ancient City should be studied and compared to see the difference. Moreover, it is recommended to study whether or not other foreigners came into contact with other parts of the city during the Dvaravati period.

9. Acknowledgement

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Low-heat sterilization system on fruit and vegetable pickling line production in packaging with high-voltage and corona-ozone technique

Boonthong Wasuri[1] and Bopit Chainok[2,*]

[1]**Industrial Arts Department, Faculty of Science and Technology, Nakhon Pathom Rajabhat University, Thailand**
[2]**Intelligent Control Innovation Department, Faculty of Science and Technology, Nakhon Pathom Rajabhat University, Thailand**

Abstract

This research presents a food product sterilization technique using Pulsed Electric Field (PEF) technology to inhibit microbial growth in food products and ozonation with low heat, and low power consumption can reduce the growth of bacteria in the container. This method allows the processing and preservation of food with no loss of nutritional value which preserves the flavor of the product to be more natural, safe for users, and easy to control. The test results of the prototype of a low-heat disinfection system with ozone technique in a high-pressure pulse were found that, at an ozone concentration of 4 ppm and a pressure of 50 KV, a frequency of 10 KHz at 20-35 minutes, the rate of the survival of the germ was significantly reduced: at 20 min sterilization, the growth rate was 270 cfu/ml, at 25 min, the growth rate was 160 cfu/ml. At 30 min sterilization, the growth rate was 47 cfu/ml, and at 35 min sterilization, the growth rate was 4 cfu/ml.

Keywords: Pulsed Electric Field (PEF), ozonation, food product sterilization

1. Introduction

Currently, most pickled vegetables and fruits still suffer from inconsistent product quality problems, due to the use of microbial fermentation methods mixed with raw materials for fermentation and the risk of food spoilage from product packaging [1]. There are some unwanted bacteria in the food and some contamination of germs in the packaging before and after the raw material is loaded. To solve the problem of deterioration during product distribution to consumers and want to establish standards for fermented food products for safety, according to the Good Manufacturing Practice (GMP) system [2], the researchers suggested the need for sterilization of fermented food products to reduce costs, time, energy, and to increase production. The fermented foods products are as shown in Figure 1.

Since fermented foods are foods that are highly acidic, and with high salinity [3], the containers used must be made of acid- and salt-resistant materials and do not cause harm to consumers in sterilization of fermented foods. The product must be heated. To stop the fermentation process and destroy bacteria that will cause product deterioration, because the product is highly acidic, only heat at the pasteurization level is used by placing containers of pickles in a hot bath of 120 - 140 degrees Fahrenheit. Hot water is filled in a hot tub to a level of one inch above the rim of the containers. The hot water temperature was raised to 180 - 185 degrees Fahrenheit. The bottles then are sterilized for 30 minutes, after that they are immediately removed from the water bath. The heating of pickles before packing is known as hot packs. It kills microorganisms from growing. However, there is another method which is heating after filling by dividing both vegetables and marinade into jars before sterilization.

Currently, food is processed into two main types: 1) Thermal processing, which is an important and traditional process to disinfect and produce safe food. It is still a consumed and used method nowadays. 2) Food processing using low heat or not using heat (non-thermal processing), which is currently being researched for new technologies for food processing and preservation instead of high-temperature methods that destroy some nutritional value and still keep the product to be most natural. An example of new technology that has been applied is Pulsed Electric Field (PEF) technology [4]. Currently, there are many research studies about the use of PEF in the food industry, such as inhibiting microbial growth in food products and ozone (ozonation) using low heat. Low power consumption can reduce the growth of bacteria in the container to be safe for consumers and easy to control [5]. The use of technology to develop food sterilization processes requires knowledge of many fields of science to be applied together in chemistry microorganisms and engineering, in order to be able to implement these methods effectively and to obtain food that is safe for consumers.

2. Materials and Methods

2.1 Pulsed Electric Field (PEF) technique is a technique to remove contaminated microorganisms in liquid food by electrophoresis process (electroporation). When liquid food is stim-

*Corresponding author; email: bopitch@npru.ac.th

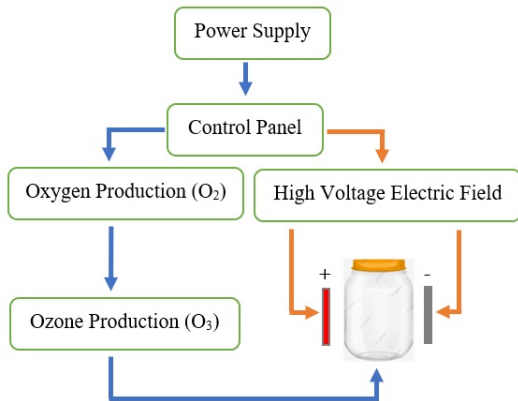Figure 1: Fermented foods products.

Figure 2: Prototype block diagram.

Figure 3: Prototype circuit diagram.

Table 1. The average ozone values in the developed disinfection cabinet and outside atmosphere.

Times (seconds)	Ozone turned on (ppm)	Ozone turned off (ppm)	Ozone output (ppm)
20	0.402	4.209	0.119
40	0.535	3.119	0.073
60	0.729	2.029	0.047
80	1.023	1.973	0.021
100	1.45	1.917	0.005
120	2.28	1.861	0.001
140	3.11	1.295	0
160	3.27	0.729	0
180	3.408	0.163	0
200	4.234	0.123	0
220	4.657	0.083	0
240	4.677	0.043	0
260	4.709	0.031	0
280	4.941	0.019	0
300	4.999	0.007	0

ulated by high electric field intensity, it produces ion mobility under pulsed electric field conditions at a repetition rate at a certain frequency [6] in a very short period of time, usually 10 - 3 to 10 - 6 sec, resulting in friction on the microbial cell wall, tearing and through pore formation. The extracellular fluid diffuses into the microbial cell around the pore formation [7]. An instantaneous increase in the internal osmotic pressure of the microbial cell occurs in the cell wall, causing the phenomenon of microbial cell proliferation from intracellular pressure until the injecting membrane was broken. That is big leading to permanent microbial cell death, while food cells that are larger than microbial cells are not affected. It is because the cell membrane of food cells has thick walls. So, there was a slight lack of injection, and food cells are able to repair themselves to their original state [8]. It was able to reduce microbial count during non-thermal processing by 4 – 6 log cfu/ml by destroying mold and yeast microorganisms in ready-to-drink juices such as orange juice, apple juice, pineapple juice, tomato juice, and water temperature. The fruit was not more than 40 °C and had a shelf life of more than or equal to 21 days at a storage temperature of not more than 7 °C. The quality, color, taste, and smell were equivalent to that of fresh fruit juice. The shelf life depends on the packaging hygiene and materials, as well as the storage conditions during transportation to the consumers. The sterilization by the pulsed high-voltage electric field is an electric current technique with high electric field intensity, using high-frequency electric field vibrations to destroy the microbial cell membrane. This makes it possible to eliminate bacteria, mold, and yeast that cause spoilage. In addition, because this process takes place at low temperatures, and in a short time,
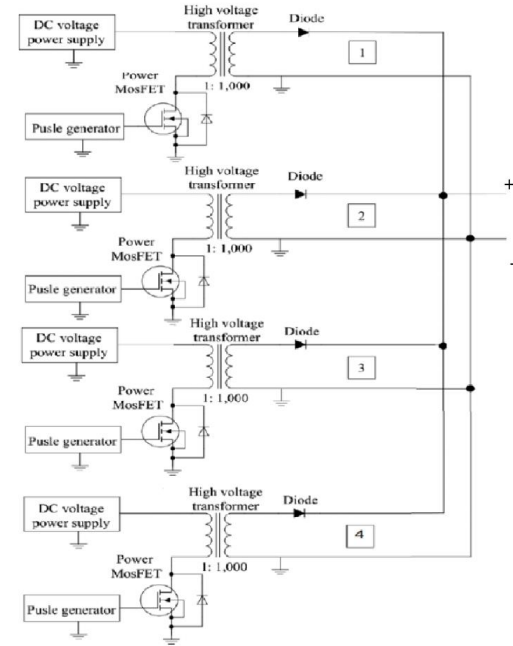
this makes it possible to preserve nutrients, freshness, and flavor without the use of additives and preservatives. The high-voltage drop across the cell membrane [9] can be calculated from the equation (1).

$$V_{cell} = f r_{cell} E_{cell} \qquad (1)$$

Where V_{cell} is the maximum voltage across the cell membrane, f is a constant that depends on the shape of the cell, r_{cell} is the outermost radius of the cell membrane and E_{cell} is the value of the electric field stress at the cell membrane.

2.2 Ozone (Ozonation) is an oxidizing agent that destroys many types of microorganisms, including bacteria, yeast, and mold. Protozoa that can cause microbial spoilage and pathogens such as Escherichia coli, Listeria, Vibrio, and Salmonella. High oxidizing ability that interferes with the transfer of charge between the cell wall layers, destroys the cell wall structure of microorganisms and destroys various elements within the cell, resulting in acute damage to microbial cells and eventually death

Table 2. The physical quality analysis of the product before after using the developed continuous low heat sterilization system.

Product	Product			
	Hardness (N)		Firmness (N/mm)	
	Before	After	Before	After
Pickled Cabbage	48.85±4.61	48.85±0.01	146.29±0.41	146.32±0.02
Pickled Ginger 3 Flavors	6,309.21±847.44	6,309.24±0.01	49.03±0.00	49.07±0.02
Pickled Lemon	6.56±2.26	6.58±0.01	418.89±0.63	418.91±0.01

**Table 3.** The colors quality analysis of the product before after using the developed continuous low heat sterilization system.

Product	Colors					
	L*		a*		b*	
	Before	After	Before	After	Before	After
Pickled Cabbage	37±6.21	37.05±0.02	0.40±1.4	0.40±1.0	23.87±6.11	23.86±0.01
Pickled Ginger 3 Flavors	51.1±6.42	51.40±0.0.20	-0.2±0.42	-0.1±0.05	25.43±1.74	25.45±0.01
Pickled Lemon	36.83±0.73	36.36±0.02	9.03±0.71	9.06±0.01	21.07±0.19	21.06±0.02
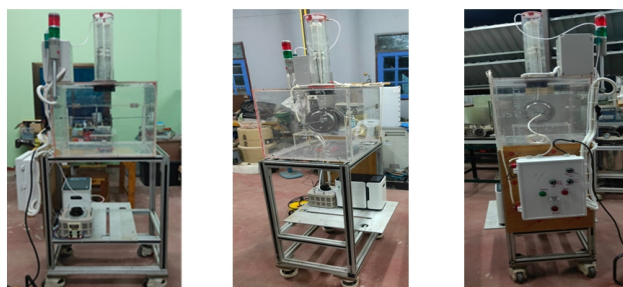
Figure 4: Prototype of a Low-heat sterilization system.

Figure 5: Low-heat sterilization system.

[10]. Currently, ozone is widely used for both disinfection and pollution removal, because ozone uses low production costs. However, there is a limitation. Ozone is harmful to humans if it is exposed to concentrations above 4 ppm continuously. Therefore, there must be a detection and alarm system with a good ventilation system in the area of use. Ozone is also a strong oxidizing agent which can corrode material surfaces. Therefore, it must be used on corrosion-resistant surfaces such as stainless steel. Nowadays, ozone has become one of the most popular methods in water treatment system, because it can remove heavy metals bacteria and odor. Additionally, it is used in the drinking water production process. Moreover, the ozone-treated water can be used for swimming pools, spas, agriculture, livestock farms, and water distribution systems.

2.3 Prototype The researchers created a prototype of a low-heat disinfection system using pulsed electric fields and ozone techniques. Its components are a high-voltage power supply, pulse electric fields ozone gas production section with corona discharge electrical, insulating, and command protection with user interface controls. Sterilization test procedure starts from putting foods in the cabinet, then setting the time for the ozone system to work, and emitting an electromagnetic field to disinfect together for about 30 minutes. This research model is shown in Figure 2, Figure 3, and Figure 4, respectively.

The researchers have developed a prototype of a low-heat sterilization system using electric field and ozone techniques for use at the laboratory level. For system structure, the pole base is made of aluminum profile and the cover is made of acrylic with the size of 50x50x100 cm. By inoculating in a petri dish and then using it for testing in the disinfection
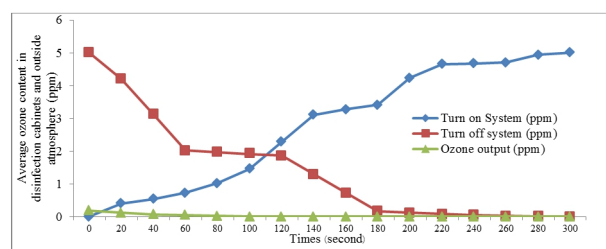
Figure 6: The relationship between time and the amount of ozone in the disinfection cabinet developed and outside atmosphere.

system, sterilization data were collected according to variables of pulse frequency, time, amount of ozone used in the system, and energy cost per area used for disinfection. A disinfection system for low heat with electric field techniques and ozone in the field based on prototype data from the laboratory was developed. The researchers tested the ozone content used in the disinfection system initially developed with a portable ozone gas detector. The results of the amount of ozone used in the developed disinfection system are shown in Table 1.

3. Results and Discussion

From Table 1, the test for the determination of ozone content used in a disinfection system was initially developed with a portable ozone gas detector. It revealed that when the system is turned on, the system can produce ozone gas in the disinfection cabinet to a concentration of 0.00 ppm. (part per million) to about 5.00 ppm. within 300 seconds, which is a concentration that can eliminate bacteria, or up to 99% of fungi within 2-5
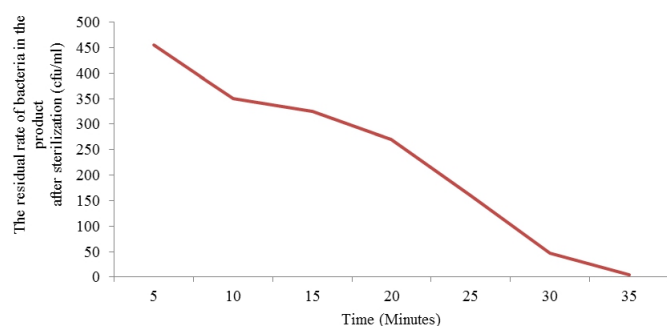
Figure 7: The relationship between time and the amount of ozone in the disinfection cabinet developed and outside atmosphere.

Table 4. Residual rate after using the prototype of a low-heat sterilization system using ozone and high-pressure pulse techniques.

Times (seconds)	The residual rate of bacteria in the product after sterilization (cfu/ml)
5	455
10	350
15	325
20	270
25	160
30	47
35	4

minutes. When the disinfection system is turned off, the system can reduce the ozone concentration in the disinfection cabinet to less than 0.100 ppm. within 180 seconds, by venting the ozone into the outside air with an extractor fan. The ozone concentration in the outside atmosphere is below 0.10 ppm. within 60 seconds, which is a certain level of operator safety. The results are shown in Figure 6. From Table 2 and Table 3, the results of the experiment compare the hardness, firmness, and colors of the sample foods. It showed that before and after using the system, the values are not much different.

When unsterilized samples of pickled lettuce and lemon from the food industry were tested, the growth of all microorganisms was found high at dilution level 101. The researchers, therefore, tested the germs obtained from the two product samples for the sterilization efficiency of a prototype low-heat sterilization system, using ozone in a strong pulse combination technique. The ozone concentration was about 4 ppm and the pressure were about 50 kV and the frequency were about 10 KHz at 5, 10, 15, 20, 25, 30, and 35 min, respectively. The growth rate of the inoculum was high (over 300 colonies/plate) at 20-35 min. As a result, it was found that the survival rate of the inoculum was significantly reduced a growth rate of 270 cfu/ml at a sterilization time of 25 minutes, a growth rate of 160 cfu/ml at a sterilization time of 30 minutes, and a growth rate of 47 cfu/ml at sterilization time of 35 minutes with a growth rate of 4 cfu/ml. The result is shown in Figure 7.

4. Conclusions

Analysis and evaluation of the engineering economics results from the conventional sterilization system to heat sterilization. Each cycle is used to boil an electric pot for producing 100 kilograms of products, using 35 electric units of energy, or about 175 baht, or 1.75 baht per kilogram. The cost of the

developed system is about 200,000 baht per batch. Continuous sterilization of pickled vegetables and fruits can be stored in the packaging on the production line for approximately 250 kg per cycle (180 minutes per cycle). In conclusion, the low heat sterilization system with high voltage and corona ozone technique has reduced the cost per cycle because the system does not use high heat energy.

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