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2. To support academicians and teachers in creating work beneficial to the academic community
3. To stimulate and support education at the university level

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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 16 Number 1 (January – February 2021). This issue contains of seven interesting articles in multidisciplinary fields: (1) Paper spray mass spectrometry: A new rapid confirmation method for methamphetamine, (2) A model for developing innovation competencies of teachers in schools under the Foundation of the Church of Christ in Thailand, (3) Developing a model of a collaborative network for promoting learning management efficiency in schools under Chiang Mai Primary Educational Service Area, (4) Quantitative ethnobotanical study of medicinal plants used by Karen people of Wah-Theinkha village in Kawmhu Township, Myanmar, (5) An optimal deposit-refund system for mitigating hazardous packaging waste in Thailand's agricultural sector, (6) Marketing mix factors affecting the frequency and loyalty in online transactions of Nakhon Pathom teenagers, and (7) Win-win or not? Factors impacting Chinese programs in Thai higher education under zero-game.

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

Yongyudh Vajaradul
Editor
Interdisciplinary Research Review

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Paper spray mass spectrometry: A new rapid confirmation method for methamphetamine

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Abstract

Paper spray mass spectrometry (PS-MS) is amenable for analyzing drugs and other compounds in biological samples. It has provided a rapid, qualitative, and quantitative ambient ionization method for biomolecules analysis to an alternative to traditional sample preparation and chromatography. This research aimed to study the efficiency of postmortem urine methamphetamine (METH) identification using PS-MS (orbitrap) compared with the Online-SPE-LC-MS/MS method. Twenty-one of METH positive urine and four METH negative urine from May 2017-Dec 2019 were randomly sampled and analyzed for METH concentration using both methods. The qualitative results obtained by the PS-MS method founding that twenty-one of METH positive urine cases were passing of three criteria parameters of PS-MS method with the true positive rate equal to 100% and the quantitative results founding that METH concentrations determined by PS-MS method were significantly higher than the results from Online-SPE-LC-MS/MS method (Paired t-Test, P-value < 0.05). PS-MS method can save time 7.5 fold as compared to the Online-SPE-LC-MS/MS method. In conclusion, PS-MS can be used for rapid screening and confirmation of urine METH.

Keywords: Methamphetamine, paper spray mass spectrometry, Orbitrap

Article history: Received 17 June 2020, Revised 24 November 2020, Accepted 24 November 2020

1. Introduction

Methamphetamine (METH) is one of the most commonly used illicit drugs in the world. [1] It is a highly addictive psycho-stimulant that belongs to a class of synthetic drugs called amphetamine-type stimulants (ATSs). [2] A new report (2020) from the United Nations Office on Drugs and Crime (UNODC) warns that the synthetic drug market in East and Southeast Asia continues to expand and diversify. The price of METH has dropped to the lowest level in a decade as the supply has surged [3] then increasing the number of Thai addictions. METH is classified as a penal drug in category-1 of the Narcotics Act, B.E. 2522; the use of METH is still prohibited. Furthermore, Narcotics Addict Rehabilitation Act, B.E. 2545 ordered the METH-addicted must be committed to rehabilitating. With the consequence of both laws, the suspect will be tested for drug use in the body, such as a urine test for METH. Urine METH concentrations greater than 1000 ng/mL are considered to exceed the legal limits. This value is called the cut-off limits, which must be examined confirmation in the next step. Forensic toxicology laboratories typically use a two-step process to detect toxicants in biological samples. The first step is screening, which employs a variety of analytical procedures to detect a broad

range of targets such as Immunoassays (IAs), gas chromatography (GC), GC-mass spectrometry (MS), liquid chromatography-MS (LC-MS) or LC-MS/MS [4] are all commonly used methods for drug screening. Positive results during the initial drug screening step are confirmed and quantitated by an independent analytical procedure. LC-MS/MS is the most widely used drug confirmation and quantitation method due to its excellent sensitivity and selectivity. In Thailand, the suspect urine will be tested twice. The first step is screening with the immune-chromatography test kit that has cut-off values according to the law. The second step confirms with Online Solid-phase extraction-liquid chromatography-mass spectrometry/mass chromatography (Online SPE-LC-MS/MS). The Confirmation step is the most time-consuming in the entire identification process [5] because it consists of the procedure for specimen preparation and chromatographic separation. Thus it takes an average of 30 minutes per sample. Paper spray MS (PS-MS) is a novel approach for rapid drug screening and confirmation. The biological sample is spotted onto a paper substrate. Upon application of a spray solvent and electric potential, extraction and ionization occur directly from the paper without any need for additional sample preparation. Then it is spending a shorter run time period (approximately 2 minutes per sample). [6] Due to its simplicity and efficacy, PS-MS has garnered significant interest. Numerous papers have published vari-

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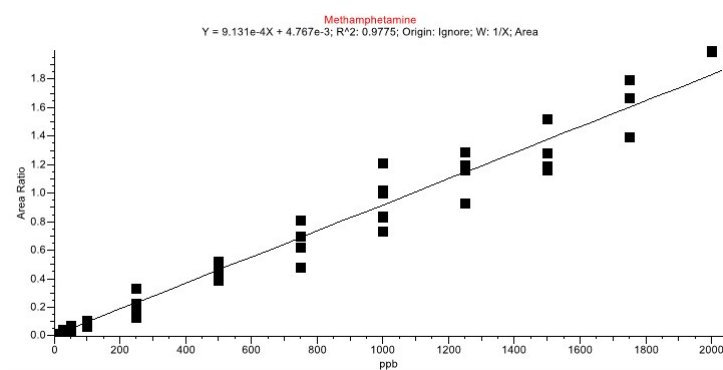


Figure 1: METH calibration curves for PS-MS.

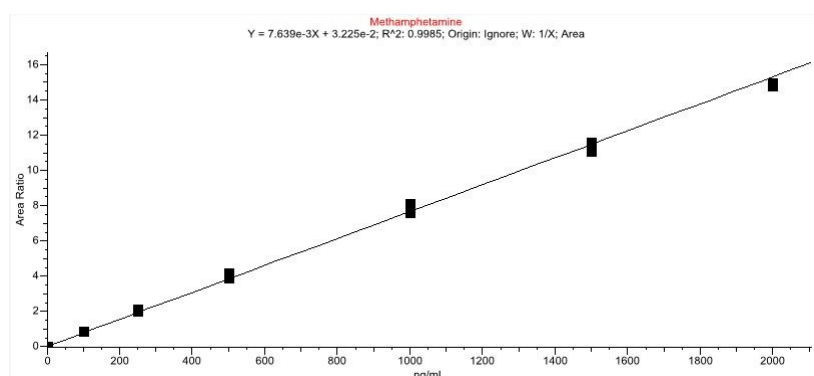


Figure 2: METH calibration curves for Online SPE-LC-MS/MS.

ous modifications, methods, and potential applications that demonstrate the rapid, quantitative power of PS-MS through targeted analysis of various molecules, including illicit drugs, therapeutic drugs, metabolites, lipids, and proteins in biomedical samples.[7 – 9] This research aims to study the efficiency of urine METH identification using PS-MS compare with the Online-SPE-LC-MS/MS method.

2. Materials and Method

Twenty-one of METH positive urine and four of METH negative urine from May 2017-Dec 2019 were randomly sampled from sample discard unit; SDU (collected the samples that cases have ended), the Institute of Forensic Medicine, Police General Hospital. The standard METH solution was obtained from the Department of Medical Sciences, Ministry of Public Health. PS-MS, PS: Prosolia Velox 360, MS: Orbitrap Q Exactive Focus and Online-SPE-LC-MS/MS, LC: Ultimate3000, MS: TSQ Quantiva were from Thermo Fisher Scientific, San Jose, CA, USA.

Trimipramine (1,000 ng/mL) was added to urine samples as an internal standard, and 10 μ L of the urine was spotted directly onto a Velox sample cartridge. The PS solvent used for extraction analyte from dry urine in the paper of a Velox sample cartridge was Acetonitrile: water: 10 M acetic acid (90: 10: 0.01). The Orbitrap mass spectrometer was operated in full-scan data-dependent MS² Mode. In this

mode, high-resolution, full-scan data at a resolution of 70000 were collected, then MS² spectra at a resolution of 35000 were triggered for compounds entered in the inclusion list. Data were acquired with TraceFinder? software, version 3.2, and analyzed with ToxFinder? software, version 1.0. This software used to identify compounds based on three parameters (1) a chromatogram peak area above a specified threshold (2) Isotopic pattern comparison, mass error NMT ± 5 ppm, and matching scores > 80% and (3) Fragment ions matching mass error NMT ± 5 ppm and a minimum of fragments needed ≥ 2 . Postmortem blank urine were spiked with standard METH at concentrations of 1, 5, 10, 25, 50, 100, 250, 500, 750, 1000, 1250, 1500, 1750 and 2000 ng/mL as a standard solution. Standard curves for PS-MS and Online-SPE-LC-MS/MS were plotted, 25 urine samples were evaluated.

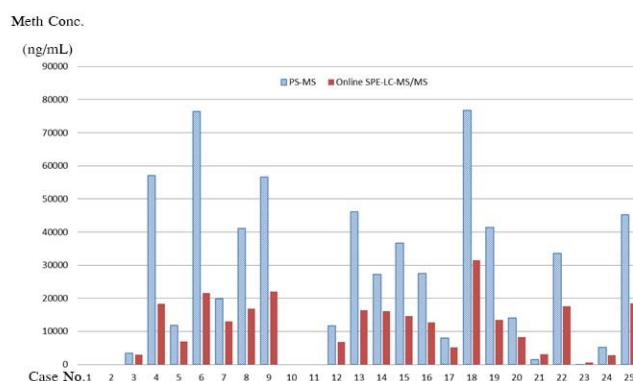
3. Results and Discussion

METH calibration curves ($n = 14$ standards, four injections per standard) for PS-MS were evaluated in the range 1 - 2000 ng/mL, showing to be linear equation $Y = 9.131 e-4x + 4.767 e-3$ with $r^2 = 0.9775$ (Figure 1) and METH calibration curves ($n = 7$ standards, two injections per standard) for Online SPE-LC-MS/MS was showing to be linear equation $Y = 7.639 e-3x + 3.225 e-2$ with $r^2 = 0.9985$ (Figure 2).

Twenty-five randomized urine samples were analyzed for METH concentrations using PS-MS and

Table 1. Differences of METH concentrations from 21 positive urine samples analyzed by PS-MS and Online-SPE-LC-MS/MS method.

Method	n	Mean (ng/mL)	Std. Deviation	Paired Differences		t	P-value
				Mean	Std. Deviation		
PS-MS	21	30517.60	23571.09	17685.39	16363.59	4.953	0.000
Online-SPE-LC-MS/MS	21	12832.22	7844.23				

**Figure 3:** The concentration of METH urine samples from 25 samples by both PS-MS and Online-SPE-LC-MS/MS method.

Online-SPE-LC-MS/MS method. The analysis results were shown in Figure 3.

The qualitative results obtained by the PS-MS method founding that twenty-one METH positive urine cases were passing of three criteria parameters of the PS-MS method with the true positive rate equal to 100%. These results indicate that the method shows good promise as a drug screening method, consistent with the study of McKenna *et al.* [10] using PS-MS (orbitrap) to screen 130 various drugs including METH in blood specimen, the true positive rate was 92.1%. The PS-MS screening needs a high true positive rate because it used high-resolution MS that presents high-quality screening outcomes. If fewer targets were included in the screening panel, the resolution could improve selectivity and sensitivity automatically.

The quantitative results obtained by the PS-MS method were compared to the Online-SPE-LC-MS/MS quantitative confirmations using Passing-Bablok regression (Figure 4). The two methods were highly correlated, with a Spearman rank correlation coefficient (r) of 0.949. The concentrations determined by PS-MS were, on average, higher than the LC-MS/MS values as reflected by the slope value of 2.8998. Although the PS-MS technique was developed as a rapid screening method and the LC-MS/MS method was developed for quantitative confirmation. However, the quantitative performance of PS-MS can be improved by decreasing the number of targets, and by using isotopically labeled internal standards for each analyte. [10] For example, McKenna *et al.* used Methamphetamine- d^{11} as an internal standard for detection METH from postmortem blood.

Differences between METH concentrations detected by both methods were analyzed using the Paired

t-Test. It was shown that the METH concentration determined by both methods were the statistically significant difference at the level of P-value < 0.05. (Table 1), consistent with slope value from Passing-Bablok regression indicated that PS solvent in this study (90: 10: 0.01 acetonitrile: water: 10 M acetic acid) more suitable for extract METH from the paper cartridge and released METH in large quantities whereas the Online SPE-LC-MS/MS may cause loss of yield from the extraction process. However, it can be done if use the PS-MS method as a qualitative confirmation method after the initial screening.

However, the total analysis time of PS-MS was much less than that of the Online-SPE-LC-MS/MS method (7.5 folds).

4. Conclusion

PS-MS is amenable for the analysis of drugs and other compounds in biological samples. In this study, the PS-MS was assessed to determine METH in postmortem urine samples compared to the standard Online-SPE-LC-MS/MS method. PS-MS showed good promise as a drug screening method in quantitative propose. METH concentrations analyzed by PS-MS were higher than the LC-MS/MS method. However, the total analysis time of PS-MS was much less than that of the Online-SPE-LC-MS/MS method. In conclusion, PS-MS (orbitrap) can be used for rapid screening and confirmation of urine METH.

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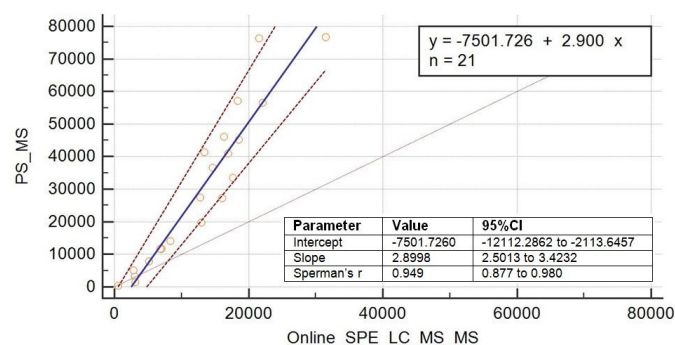


Figure 4: Comparison of METH concentrations from 21 positive urine samples by both PS-MS and Online-SPE-LC-MS/MS method. The Passing-Bablok regression was shown as a solid line. The $\pm$ 95%CI was shown as a dashed line.

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A model for developing innovation competencies of teachers in schools under the Foundation of the Church of Christ in Thailand

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Abstract

This research is aimed 1) to synthesize elements of innovation competencies of teachers, 2) to investigate conditions, problems, and guidelines for developing innovation competencies of teachers, 3) to develop a model for developing innovation competencies of teachers in schools under the Foundation of the Church of Christ in Thailand. Instruments used in this research were a synthesized record form, a confirmation questions, and a verified form. Data were analyzed by frequency, mean, standard deviation, and content analysis and synthesis. Results of the research were as follows: 1) innovation competencies of teachers consisted of 5 elements with 13 indicators. 2) conditions of practicality were the methods that created innovations, cooperation, and teamwork; problems encountered were not that teachers changed teaching methods and innovations to be the problems; while the guidelines consist of the developing process for teachers' to develop innovation competencies including five aspects and the developing method to achieve greater efficient and effective performance on their teaching duties through eight different methods. 3) a draft model is constructed for developing innovation competencies of teachers in schools under the Foundation of the Church of Christ in Thailand consisting of five components and twenty-eight sub-components.

Keywords: A developing model, innovation competencies, schools under the Foundation of the Church of Christ in Thailand

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1. Introduction

Due to the development of education management in order to have better quality and an acceptable standard, educational institutions have to play a role in developing students to be the quality adults in the future. The focal point of education is to drive the teachers' educational and knowledge development process. Teachers are the most meaningful and important factors in the classroom because the quality of the learners are based on the quality of the teachers. The Office for Promotion of Learning Society and the Quality of Youth [1] in line with the Office of the Education Council (ONEC), Ministry of Education [2] also realized that the teachers were the most important personnel to enhance and improve the quality of education because of the teachers' knowledge and their teaching competencies lead to the students' learning outcomes for society's expectation.

Moreover, the Secretariat of the House of Representatives [3] mentioned that the status and problems with education which occurred in Thai society over the past years, and arose for by a variety of reasons: the organizational structure and the educational management system, educational institutions, as well as

schools, teachers, learners and other relevant sectors. These causes were interrelated and affected the overall quality of education in the country. One of the important problems was the teachers. Whenever there was any educational reform, teachers were involved every time with many dimensions specially, problems arising from the organizational structure, the educational management system, and problems arising directly from the teachers.

The same was the case noted by the educational institutions of the Thailand Development Research Institute [4]. In order to raise the educational quality, teachers therefore had to enhance their own professions, and develop skills and operational competencies appropriate to the changing situation. The teachers would then develop by competencies and performances which would affect the learners. Teachers had to improve their knowledge and traditional teaching and learning methods to meet the new desirable competencies.

According to Chang *et al.* [5] who investigated teachers' core competencies in relation to their innovative teaching performances, four competencies (learning competency, educational competency, social competency and technological competency) were theorized as the core competencies for teachers' innovative teaching. Similar to the finding of Arisa *et al.* [6],

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the salient points found that, as whole the needs for teacher competency development required at a three-highest levels; namely, innovation and communication technology, learning management, and measurement and evaluation.

Additionally, Mike and Rachel [7] indicated the innovation competencies and mindsets consisted of creativity, initiative, teamwork, networking, collaboration, visioning, enterprising, intelligent risk-taking, critical thinking, challenging the status quo, identifying problem, intellectual curiosity, flexibility, perceptiveness, positive self-efficacy, effective communication, and leadership.

However, problems were noted that some schools under the Foundation of the Church of Christ in Thailand had decreased student numbers. Some of those teachers lacked good morale and moral support affecting to the quality of teaching and learning management. The research results of the Educational Research Center [8] revealed that most of the problems were personnel problems such as the teachers lacked of skills in researching and using innovation, and technology media, and the schools lacked professional development for teachers. Just like Apidech and Santchai [9], who had studied the management strategies of small school of the Foundation of the church of Christ in Thailand, their findings showed that one of the main strategies was to reform academic administration in order improve the quality of education to respond to the national education plan that is suitable for the needs of the community and society and essential skills in the 21st century and the global change in the digital age.

Considering all this, the researcher, positioned as a school administrator realized that teachers should be trained in accordance with creating innovation competencies to increase the higher potential of students and create learners to be capable thinkers of creating new innovations to cope with the future. Therefore, it is essential to construct a model for developing innovation competencies of teachers in schools under the Foundation of the Church of Christ in Thailand in order to develop teachers to achieve the educational results.

2. Research Questions

2.1 What are elements of innovation competencies and how many elements?

2.2 What are conditions, problems, and guidelines for developing innovation competencies of teachers in schools under the Foundation of the Church of Christ in Thailand?

2.3 What is a model for developing innovation competencies of teachers in schools under the Foundation of the Church of Christ in Thailand?

3. Research Objectives

3.1 To synthesize elements of innovation competencies of teachers in schools under the Foundation of the Church of Christ in Thailand.

3.2 To investigate conditions, problems, and guidelines for developing innovation competencies of teachers in schools under the Foundation of the Church of Christ in Thailand.

3.3 To develop a model for developing innovation competencies of teachers in schools under the Foundation of the Church of Christ in Thailand.

4. Materials and Methods

The research process was divided into three phases as follows:

Phase 1: Synthesize the elements of innovation competencies of teachers in schools under the Foundation of the Church of Christ in Thailand. This phase was divided into two steps:

Step 1.1: The researchers synthesized the elements of teachers' innovation competencies from the concepts of seventeen educators both Thai and foreigners. The instrument used was a synthesized record form. Then data were analyzed by frequency.

Step 1.2: The confirmation of elements concerning the teachers' innovation competencies under the Foundation of the Church of Christ in Thailand, key informants were twelve experts positioning as administrators under the Foundation of the Church of Christ in Thailand selecting by purposive sampling to participate in connoisseurship, instrument used was a confirmation question form. Data were analyzed by content analysis.

Phase 2: Investigate the conditions, problems, and guidelines for developing innovation competencies of teachers in schools under the Foundation of the Church of Christ in Thailand. This phase was divided into 2 steps:

Step 2.1: Investigate the conditions of practicality and problems for developing innovation competencies of teachers in schools under the Foundation of the Church of Christ in Thailand, key informants were seven academic administrators under the Foundation of the Church of Christ in Thailand, instrument used was an in-depth interview to inquire the conditions of practicality / problems. Data were analyzed by summarizing.

Step 2.2: Investigate the guidelines for developing innovation competencies of teachers in schools under the Foundation of the Church of Christ in Thailand. Instrument used was a synthesized form concerning the developing process of innovation competencies of teachers and the developing method of innovation competencies of teachers. Data were analyzed by content analysis.

Phase 3: Develop a model for developing innovation competencies of teachers in schools under the

Table 1. Results of synthesizing of the elements of innovation competencies of teachers in schools under the Foundation of the Church of Christ in Thailand.

Innovative elements	Innovative indicators	G. Dyer, 2011	B. Drew, 2011	Z. Chang, 2013	D. Lolly, 2014	K. Pradeep, 2016	OECD, 2017	P.K.John, 2018	T. warker, 2018	H. Jeera, 1997	T. Pasu, 2002	S. Narucha, 2003	S. Wasan, 2014	S. Wasan 1, 2016	S. Wasan 2, 2016	S. Paitoon, 2016	T. Kaweesut, 2017	S. Pruk, 2017	Frequency (17)
Innovative and productive thinking.	Innovative creativity.	✓	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	15
	Integration thinking.	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓			✓	13
	Creative problem solving and productive thinking.	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓		✓	14
	Accountability.	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓				12
Learning management to construct innovation.	Innovative knowledge and innovative process.	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	15
	Classroom management to promote learning.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	16
Cooperation and team-work.	Interactive exchanging.	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓					✓	✓	13
	Communication was created understanding.	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓					✓	✓	13
	Having a cooperative network to develop collaborative innovation	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓					✓	✓	13
Continuous self-development.	Open-minded for loving learning.	✓	✓			✓	✓	✓	✓			✓	✓	✓	✓			✓	12
	Seeking self-development opportunities.	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓			✓	13
Being a good role model.	Having passion for working.	✓	✓	✓	✓	✓		✓	✓	✓		✓					✓	✓	12
	Having teachers' spirit and living according to teachers' professional conducts.	✓	✓	✓	✓	✓		✓	✓	✓		✓					✓	✓	12

Foundation of the Church of Christ in Thailand, the researcher divided into two steps as follows:

Step 3.1: Construct a model for developing innovation competencies of teachers in schools under the Foundation of the Church of Christ in Thailand. The researcher analyzed the model components and synthesized the results of phase 1 and phase 2 in order to construct a model for developing innovation competencies of teachers in schools under the Foundation of the Church of Christ in Thailand. Key informants consisted of nine experts positioning as administrators or educational counselors under the Foundation of the Church of Christ in Thailand and educational educators. Instruments used were issues for focus group discussion and a record form. Data were analyzed by content analysis.

Step 3.2: The formal key informants from step 3.1 also verified and improved model components and sub-model components for developing innovation competencies of teachers in schools under the Foundation of the Church of Christ in Thailand. Then data were analyzed by classified issues.

5. Results and Discussion

Phase 1: Synthesize of the elements of innovation competencies of teachers in schools under the Foundation of the Church of Christ in Thailand. This phase divided into two steps:

Step 1.1: Six elements of teachers' innovation competencies in schools under the Foundation of the

Church of Christ in Thailand were derived consisting of: 1) creative thinking, 2) questioning, 3) interaction and having a network, 4) linking of ideas and imagination, 5) observation, and 6) experiment and test new ideas as shown in Table 1.

Step 1.2: The confirmation results of elements concerning the teachers' innovation competencies in schools under the Foundation of the Church of Christ in Thailand were derived from the participation of twelve experts as key informants in connoisseurship to correct and improve the indicators of the innovative elements consisting of 5 elements with 13 indicators as shown in Table 2.

It was similar to Peerawat and Karn [10] who studied the development of guidelines to enhance teachers' competency in self-development. The results revealed that there were 4 elements and 12 indicators of the guidelines; concerning the fourth element was sharing opinion and networking among professional community comprised of 1) studying the literature and related documents, 2) being member of the professional organization, and 3) being a leader to enhance competency. Moreover, it was also similar to Kathy *et al.* [11] who divided it into four key elements of innovation: collaboration, ideation, implementation and value creation.

Phase 2: Investigate the conditions, problems, and guidelines for developing innovation competencies of teachers in schools under the Foundation of the Church of Christ in Thailand. This phase was divided into two steps:

Table 2. Results of agreement and disagreement of innovative elements and innovative indicators by twelve experts.

Innovative elements and innovative indicators	Agree	Disagree
1. Innovative and productive thinking.		
1.1 Innovative creativity.	12	
1.2 Integration thinking.	11	1
1.3 Creative problem solving and productive thinking.	12	
1.4 Accountability.	12	
2. Learning management to construct innovation.		
2.1 Innovative knowledge and innovative process.	11	1
2.2 Classroom management to promote learning.	12	
3. Cooperation and teamwork.		
3.1 Interactive exchange.	11	1
3.2 Communication was created understanding.	11	1
3.3 Having a cooperative network to develop collaborative innovation.	12	
4. Continuous self-development.		
4.1 Open-minded for loving learning. 11 1		
4.2 Seeking self-development opportunities. 10 2		
5. Being a good role model.		
5.1 Having passion for working.	10	2
5.2 Having teachers' spirit and living according to teachers' professional conducts.	10	2

Step 2.1: Results of investigating the conditions and problems for developing innovation competencies of teachers in schools under the Foundation of the Church of Christ in Thailand, the findings in terms of its practicality / problems were shown in Table 3.

It was similar to the findings of Anusorn *et al.* [12], which revealed that innovative leadership consists of 5 components: 1) innovative vision and strategies, evaluating the innovative leadership development model of Sarasas Affiliated Schools administrators, 2) innovative thinking skills, 3) innovative organization atmosphere creation, 4) risk management and 5) innovative network creation. Innovative leadership development guideline consists of 6 steps: 1) presenting information, 2) individual processing, 3) sharing knowledge for group agreement, 4) presenting innovation for success, 5) criticizing conclusion for action and 6) evaluating the development by indicators

Step 2.2: Results of guidelines for developing innovation competencies of teachers in schools under the Foundation of the Church of Christ in Thailand were divided into two parts as shown in Table 4.

In line with Panavee and Vorachai [13], who studied the guidelines for development of teachers' core competencies, it was found that the school administrators support teachers' teamwork, build teachers' networks, organize a mentor system, implement a coaching system and have a supervision and monitoring system in place.

Phase 3: Results of developing the model for developing innovation competencies of teachers in schools under the Foundation of the Church of Christ in Thailand, the researcher divided into 2 steps as follows:

Step 3.1: Construct a draft model for developing innovation competencies of teachers in schools under the Foundation of the Church of Christ in Thailand consisting of six components as follows: 1) the model

principle and rationale of the model, 2) the model objectives, 3) the operational method of the model, 4) the model measurement and evaluation, 5) the model conditions for achievement, and 6) the model manual in accordance with Teera [14], the model was divided as follows: 1) objectives, 2) principles, 3) systems and mechanisms, 4) operating methods or procedures, 5) successful indicators, 6) definitions and description, and 7) conditions for achievements of model implementing and similar to Chawinnawat [15] who found that the integrated administration model for enhancing quality of world class standard schools was composed of principle, objectives, system, mechanism and operational methods.

Step 3.2: The developed model for developing innovation competencies of teachers in schools under the Foundation of the Church of Christ in Thailand was verified and improved by school principals for administrators and practitioners as shown in Table 5.

6. Conclusion

According to the developed model of innovation competencies of teachers in schools under the Foundation of the Church of Christ in Thailand, teachers must have a variety of processes for developing and leading to be an innovative teacher who can create their own innovation. However, if any educational organizations can develop teachers to achieve these core innovative competencies that are mentioned above, they will make the organization to have quality teachers and have an organizational culture to create innovation facing the challenges of a changing world including leading to be a modern organization affecting the efficiency, effectiveness, and success of the organization.

Table 3. Results of conditions of practicality and problems for developing innovation competencies of teachers were classified by each elements.

No.	Innovative elements	Conditions of practicality	Problems
1.	Innovative and productive thinking.	1. The knowledge of creative thinking and process leading to create innovations was provided for teachers. 2. Teachers sought new knowledge and use different ideas leading to create innovations. 3. Teachers had tried to create innovations or new things for solving classroom learning management problems.	1. Teachers' innovations that had published were not really new innovations. 2. Some teachers had misunderstandings concerning innovations that must be difficult. 3. The created innovations could not solve classroom learning management problems. 4. Teachers were unable to properly connect integrative thinking leading to the creation of appropriate innovations.
2.	Learning management to construct innovation.	1. Teachers created innovative teaching by focusing on activities and thinking processes that encouraged learners to think, do, and also use digital technology. 2. Teachers focused on making learning media with digital technology to promote learning.	1. Teachers still used very few questions to encourage learners to think. 2. Some teachers identified answers before encouraging learners to think. 3. Teachers should be educated in order to create more educational innovations clearly. 4. Schools must support teachers as the schools' innovators to build professional teachers.
3.	Cooperation and teamwork.	1. The schools had built a co-working space for the interaction of teachers' different individuals. 2. A variety of communicative forms were developed leading to a mutual understanding network within the schools.	1. Communication of understanding within the large schools is sometimes difficult for building the cooperation and teamwork. 2. Communication within the group sometimes make a misunderstanding for a cooperative network to develop collaborative innovation.
4.	Continuous self-development	1. Teachers continually develop themselves according to teacher development regulations. 2. Most schools give teachers the opportunity for further study and school visit. 3. Teachers are supervised on teaching and learning through lesson study model in PLC group.	1. The teacher has not applied the developed knowledge to actually use it or share with their colleagues as they should be.
5.	Being a good role model.	1. Schools stimulated and inspired teachers for working to drive the schools under the system dynamics thinking. 2. Teachers practices themselves according to the teacher's professional conducts and are responsible for their duties.	1. Appreciation, award, and feat were set by the schools which may not meet the needs of some teachers. 2. Lack of promotion / practical review in order to emphasize on the role of teachers within the framework of teachers professional conducts.

7. Recommendations

1. Educational institutions under the Foundation of the Church of Christ in Thailand should collaboratively stipulate the curriculum for developing innovative competencies in accordance with the same as the direction innovation competencies of teachers

2. The responsible persons for overseeing educational institutions under the Foundation of the Church of Christ in Thailand should promote the knowledge transferring within and among the schools or encouraging to build professional learning communities

among schools in order to share knowledge and experiences of the schools with the different contexts because the creation of innovation must be based on a wide range of knowledge and experiences.

8. Recommendation for Further Research

1. There should be the additional study concerning the learning process of the teachers to encourage teachers to provide active learning activities for the students to have learning by doing and can carry

Table 4. Results of two guidelines for developing innovation competencies of teachers in schools under the Foundation of the Church of Christ in Thailand.

Part 1: The developing process consisted of five aspects as follows:	Part 2: The developing method to achieve greater efficiency and effective performances of their teaching duties could be achieved eight different methods:
1.1) studying the conditions and problems for developing innovation competencies,	2.1) training,
1.2) target determination and objectives,	2.2) self-study,
1.3) preparation of a development project and designing the methods for developing innovation competencies,	2.3) field trips,
1.4) operations for developing innovation competencies, and	2.4) online system development,
1.5) development evaluation and the impact after implementing model	2.5) job coaching,
	2.6) learning from experts,
	2.7) learning from mentors, and
	2.8) professional learning community.

Table 5. Results of verifying and improving components and sub-components of the draft model for developing innovation competencies of teachers in schools under the Foundation of the Church of Christ in Thailand.

Model components	Model Sub-components
1. Model principle and rationale of the model consisted of 4 sub-components.	1.1 Prepare teachers to produce learners to be innovators in accordance with the 20-Year National Strategy Development Plan / Thailand 4.0 policy 1.2 Active Learning Management / 21st. Century 1.3 Creating learners to become self-knowledge creators. 1.4 Support for learning networks among schools.
2. Model objectives consisted of 2 sub-components.	2.1 Development of innovation competencies of teachers. 2.2 Development of a professional learning community (PLC) network among schools under the Foundation of the Church of Christ in Thailand.
3. The operational method of the model consisted of 4 sub-components.	3.1 Teachers' development plan (Plan). 3.2 The operations of teachers' development (Do). 3.3 Follow-up teacher development results (Check). 3.4 Application of the results for further improvement of teacher development (Act).
4. Model condition of achievement consisted of 5 sub-components.	4.1 Must have an understanding with schools administrators concerning a model for developing innovation competencies of teachers in schools under the Foundation of the Church of Christ in Thailand. 4.2 Schools administrators realize on the importance of implementing the model by following the teacher a manual for implementing model, support, and assist to set up time, budget, and the necessary technology. 4.3 Academic administrators recognize the importance of teachers' development, supervision, and follow-up continuously. 4.4 Set goals for the development of each competency topics to produce tangible results. 4.5 Teachers must apply the development knowledge to design the classroom learning management.
5. Model manual consisted of 8 sub-components.	5.1 Purposes of the manual. 5.2 Introduction. 5.3 Background knowledge of teachers innovation competencies. 5.4 A model for developing innovation competencies of teachers in schools under the Foundation of the Church of Christ in Thailand. 5.5 Roles of administrators and teachers. 5.6 The operational procedures. 5.7 Evaluation of model implementation. 5.8 References.

on summarizing their own knowledge, if so, then the teachers will have more guidelines into practice.

2. The model should be used for implementing to the other educational institutions except the schools under the Foundation of the Church of Christ in Thailand in order to study the results of the development of innovative competencies of teachers in the different contexts from this purposive group.

3. This development model should be applied to

develop other teachers' competencies under the Office of The Basic Education Commission.

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Developing a model of a collaborative network for promoting learning management efficiency in schools under Chiang Mai Primary Educational Service Area

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Abstract

This research aimed 1) to identify network components, the network management process, and success factors; 2) to investigate the conditions, problems, and success factors, and 3) to develop a model and a manual for implementing model. Instruments used were a synthesized record form, a confirmative form, a five-rating scale questionnaire, and a verified form. Data were analyzed by frequency, mean, standard deviation, summarizing, synthesizing, and content analysis. Results of the research were as follows: 1) synthesized results consisted of important network components, the network management process, and success factors; 2) results of investigating the conditions, problems, and success factors found that the total average of the important network components, and the network management process in terms of conditions were at a low level, the problems were at a high level; and total average of success factors of a collaborative network in terms of the conditions were also at a high level; and 3) results of a draft model consisted of six components verifying the correction and the suitability at 97.51 and 95.97 percent; the draft manual for implementing model consisted of seven components verifying the correction and the suitability at 93.01 and 92.71 percent.

Keywords: Model of a collaborative network, learning management efficiency, Chiang Mai Primary Educational Service Area

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1. Introduction

According to Daniel *et al.* [1] who revealed that since 2011, the collaboration and networking had recently come to the fore as major school improvement strategies in a number of countries. A variety of initiatives, from government and other agencies, had encouraged collaboration and led to a lot of practical activity in this area.

In line with the Office of the Education Council (ONEC) [2] proposed a collaborative network management model as a suitable management for basic educational institutions leading to assist and support one another for improving the educational quality.

However, Paul [3] stated that the challenges to inter-school collaboration that it was concluded that the most findings concerning the barriers from the start were the effectiveness and sustainability of inter-school collaboration, imbalances among schools; extra workload related to the collaborative activity and challenges in setting up sharing objectives and common goals.

Later, Office of the Basic Education Commission (OBEC), Ministry of Education recognized the importance of educational management focusing on the development and improvement educational quality including promoting and supporting all levels of learning exchange stages. Therefore, network groups for promoting educational efficiencies were established as follows: 1) kindergarten, 2) primary, and 3) lower and higher secondary, including educational quality centers to be a mechanism for driving the educational quality for the development of learning areas and determined the strategic of educational development (as cited in Yongyouth and Choocheep) [4].

This led to the National Scheme of Education B.E. 2560-2579 (2017-2036) which had determined the improvement, solving problems, and developing human resource management system involving administrators, teachers, and education personnel which would result for the educational agencies and institutions to be able to manage and provided education that showed responsibility for quality standards for learners more effectively and efficiently including promoting collaborative networks in improving the educational quality (Office of the Education Council: ONEC) [5]

Due to the failure of continuous educational man-

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agement, the researcher as a school administrator realized that it would be necessary to build a collaborative network for promoting learning management efficiency for development and improvement educational quality including the promotion and support of learning exchange stages for schools under Chiang Mai Primary Educational Service Area. After this, it would be crucial to develop a model for the collaborative network for promoting learning management efficiency in schools under Chiang Mai Primary Educational Service Area in order to develop learning and teaching activities to achieve the educational policy.

2. Research Questions

2.1 What are the network components, the network management process, and success factors of a collaborative network for promoting learning management efficiency in schools under Chiang Mai Primary Educational Service Area?

2.2 What are the conditions, problems, and success factors of a collaborative network for promoting learning management efficiency in schools under Chiang Mai Primary Educational Service Area?

2.3 What would be a draft model and manual for implementing model of a collaborative network for promoting learning management efficiency in schools under Chiang Mai Primary Educational Service Area?

3. Research Objectives

3.1 To identify the network components, the network management process, and success factors of a collaborative network for promoting learning management efficiency in schools under Chiang Mai Primary Educational Service Area.

3.2 To investigate the conditions, problems, and success factors of a collaborative network for promoting learning management efficiency in schools under Chiang Mai Primary Educational Service Area.

3.3 To develop a draft model and manual for implementing a model of a collaborative network for promoting learning management efficiency in schools under Chiang Mai Primary Educational Service Area.

4. Materials and Methods

The research process was divided into three phases as follows:

Phase 1: Identify the network components, the network management process, and success factors of a collaborative network for promoting learning management efficiency in schools under Chiang Mai Primary Educational Service Area. This phase was divided into two steps:

Step 1.1: Synthesize the network components, the network management process, and success factors by studying principles, concepts, theories, and related

research. Instrument used was a synthesized form and data were analyzed by classifying.

Step 1.2: Verify and confirm the network components, the network management process, and success factors by twelve experts who were selected by purposive sampling participating in a focus group discussion. Instrument used was a record form, and data were analyzed by using frequency.

Phase 2: Investigate conditions, problems, and success factors of a collaborative network for promoting learning management efficiency in schools under Chiang Mai Primary Educational Service Area. Instrument used was a five-rating scale questionnaire investigating conditions, problems, and operational results, and success factors of collaborative network for promoting learning management efficiency in schools under Chiang Mai Primary Educational Service Area. Data were analyzed by mean and standard deviation.

Phase 3: Develop a model and a manual for implementing model of the collaborative network for promoting learning management efficiency in schools under Chiang Mai Primary Educational Service Area. This phase was divided into two steps as follows:

Step 3.1: Draft the model and manual for implementing a model of a collaborative network for promoting learning management efficiency in schools under Chiang Mai Primary Educational Service Area. The researcher analyzed the obtained data from Phase 1, and Phase 2 in order to draft the model and manual for implementing a model of the collaborative network for promoting learning management efficiency in schools under Chiang Mai Primary Educational Service Area. Key informants consisted of twenty-one experts who participated in a workshop to determine the model components. Instruments used were issues from the obtained data from phase 1, and phase 2. Data were analyzed by content analysis.

Step 3.2: Verify the draft model and a draft manual for implementing model of the collaborative network. Eleven experts were selected by purposive sampling participating in connoisseurship to verify and evaluate the draft model and a draft manual for implementing model. Instruments used for verifying the correction and the suitability of the model and manual for implementing model of the collaborative network were a checklist form and open-ended questions to fill in each model component. Data were analyzed by frequency and summarizing the content. The research framework was as shown in Figure 1.

5. Results and Discussion

Phase 1: Results of identifying network components, the network management process, and success factors of a collaborative network for promoting learning management efficiency in schools under Chiang Mai Primary Educational Service Area were divided into two steps:

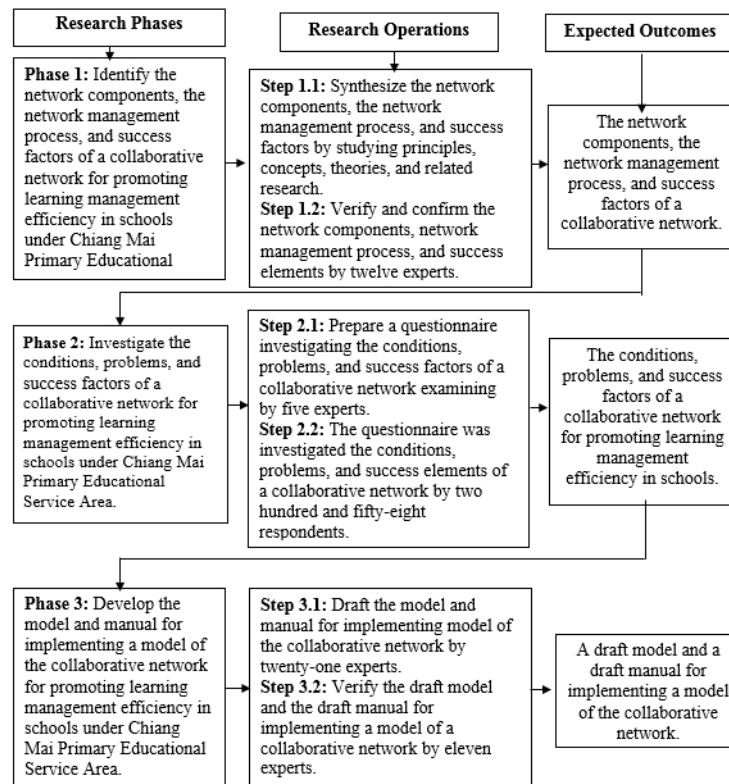


Figure 1: Research framework.

Step 1.1: Results of synthesizing the network components, the network management process, and success factors consisted of:

The important components of a collaborative network comprised of three components as follows: 1) the network purposes consisted of a network philosophy, a shared vision of the network, and network objectives; 2) the network committee consisted of a network advisory committee and a network management committee; and 3) a collaborative mission.

The network management process comprised of six steps as follows: 1) a shared thinking step, 2) a shared planning step, 3) a shared operations step, 4) a shared supervision and follow-up step, 5) an evaluation step, and 6) a success appreciation step.

Success factors of a collaborative network comprised of four elements as follows: 1) man, 2) materials, 3) money, and 4) management.

Step 1.2: Results of verifying and confirming the important network components, the network management process, and success factors consisted of:

The important components of a collaborative network comprised of three components as follows: 1) the network purposes consisted of 1.1) a network philosophy (4 sub-components), 1.2) a shared vision of the network (4 sub-components), and 1.3) network objectives (3 sub-components); 2) the network committee consisted of 2.1) a network advisory committee (1 sub-component), and 2.2) a network management committee (5 sub-components); and 3) a collaborative

mission (4 sub-components).

The network management process comprised of six steps as follows: 1) a shared thinking step (4 sub-steps), 2) a shared planning step (5 sub-steps), 3) a shared operations step (7 sub-steps), 4) a shared supervision and follow-up step (5 sub-steps), 5) an evaluation step (5 sub-steps), and 6) a success appreciation step (5 sub-steps).

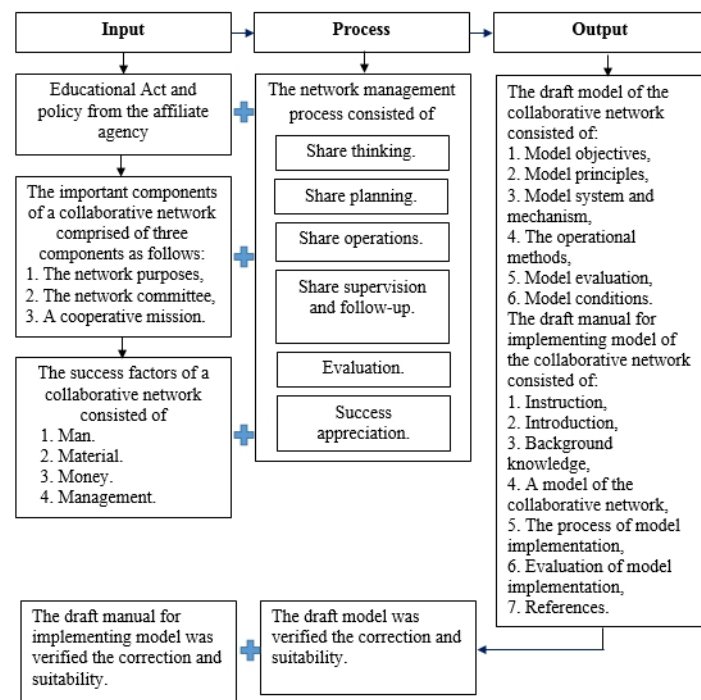
The success factors of a collaborative network comprised of four elements as follows: 1) man (8 sub-elements), 2) material (5 sub-elements), 3) money (5 sub-elements), and 4) management (8 sub-elements).

It was similar to Martin [6] who laid out four key action steps to developing a successful network: 1) organize people around a shared vision and purpose; 2) design an organizational structure that will pave the road to success; 3) cultivate a culture of engagement and shared responsibility; and 4) continuously develop the network's capacity, capability, and purpose.

Phase 2: Results of investigating the conditions, problems, and success factors of a collaborative network for promoting learning management efficiency in schools under Chiang Mai Primary Educational Service Area found that the total average of the important network components in terms of the conditions were at a low level (Mean = 2.46, S.D. = 0.80), the problems were at a high level (Mean = 4.03, S.D. = 0.58); total average of the network management process in terms of the conditions were at a low level (Mean = 2.46, S.D. = 0.82), the problems were at a high level

Table 1. Mean and standard deviation levels of the important network components were classified by each aspect.

Network components	The conditions			The problems		
	Mean	S.D.	Interpret	Mean	S.D.	Interpret
1. Network purposes						
1.1 Network philosophy.	2.54	0.72	Moderate	3.93	0.55	High
1.2 Shared vision of the network.	2.45	0.86	Low	3.98	0.64	High
1.3 Network objectives.	2.50	0.95	Low	4.25	0.67	High
Total average of network purposes.	2.50	0.79	Low	4.06	0.52	High
2. Network committee						
2.1 Network advisory committee.	2.27	1.11	Low	3.96	1.01	High
2.2 Network management committee.	2.40	0.76	Low	3.82	0.60	High
Total of network committee.	2.33	0.89	Low	3.89	0.71	High
3. A collaborative mission	2.56	0.85	Moderate	4.14	0.79	High
Total average of the important network components.	2.46	0.80	Low	4.03	0.58	High

**Figure 2:** The draft model of the collaborative network for promoting learning management efficiency in schools under Chiang Mai Primary Educational Service Area.

(Mean = 3.96, S.D. = 0.62); and total average of success factors of a collaborative network in terms of the conditions were at a high level (Mean = 3.98, S.D. = 0.59); the details were shown in Table 1, Table 2, and Table 3.

Similarly, Chirapat *et al.* [7] studied an administrative network model for academic collaboration of schools in remote highlander areas. The research found that the network committee consisted of the committee of primary office service area and the role of the committee of primary office service area, the committee of network and the role of the committee of network.

It was quite different from Jane [8], who mentioned four network principles for collaboration success involving the Energy Foundation case that illustrated the four network principles, other successful networks

that they had studied in microfinance, international development, environmental conservation, and human services exhibit these principles as well.

Similarly, Wannapan [9] studied success factors and problems in the project management at Mahidol University International College. It was found that the elements contributing to successful project management in the personnel aspect included the network of the executives or superiors, the ability of the project manager or the main project operator to comprehensively study and understand the contents of the project well, and the collaboration of internal and external staffs as a good team. The most significant success factor was careful management of the budget.

Phase 3: Results of developing the model and manual for implementing model of the collaborative network for promoting learning management efficiency

Table 2. Mean and standard deviation levels of the network management process were classified by each aspect.

The network management process	The conditions			The problems		
	Mean	S.D.	Interpret	Mean	S.D.	Interpret
1. A shared thinking step.	2.50	0.94	Low	4.00	0.66	High
2. A shared planning step.	2.47	0.92	Low	4.05	0.74	High
3. A shared operations step.	2.47	0.84	Low	4.01	0.60	High
4. A shared supervision and follow-up step.	2.46	0.86	Low	4.03	0.77	High
5. An evaluation step.	2.42	0.86	Low	3.79	0.68	High
6. A success appreciation step.	2.44	0.79	Low	3.86	0.70	High
Total average of the the network management process.	2.46	0.82	Low	3.96	0.62	High

Table 3. Mean and standard deviation levels of success factors of a collaborative network were classified by each aspect.

Success factors	The conditions		
	Mean	S.D.	Interpret
1. Man.	4.17	0.64	High
2. Material.	3.80	0.79	High
3. Money.	3.67	0.79	High
4. Management.	4.30	0.68	High
Total average of success factors.	3.98	0.59	High

in schools under Chiang Mai Primary Educational Service Area were divided into two steps as follows:

Step 3.1: The draft model of the collaborative network for promoting learning management efficiency in schools under Chiang Mai Primary Educational Service Area consisted of six components as follows; 1) the model objectives, 2) the model principles, 3) the model system and mechanism, 4) the operational methods, 5) the model evaluation, and 6) the model condition. The draft manual for implementing a model consisted of seven components as follows: 1) instruction, 2) introduction, 3) background knowledge, 4) a model of the collaborative network, 5) the process of model implementation, 6) evaluation of model implementation, and 7) references.

Step 3.2: Results of verifying the draft model in terms of correction and the suitability were at 97.51 and 95.97 percent. The draft manual for implementing model in terms of correction and the suitability were at 93.01 and 92.71 percent. The details are shown in Table 4.

Similarly, Namfon [10] studied the development of a collaborative network model enhancing basic education quality: In the case of Phayao model, the research found that: there were 4 components 1) the principle of the collaborative network, 2) the objective of collaborative network, 3) the role of committee of a collaborative network, 4) the operational process of a collaborative network. Besides, the research found that the suitable model as well as enhancing the quality of basic education was rated at a high level of feasibility and at the highest level all of utility.

Moreover, Noppapadon *et al.* [11] studied a proposed model for school network management of the Primary Educational Service Area Office. The results showed that the features and style elements consisted of six components. 1) The purpose of the school network which is detailed in five parts, 2) the structure

of the school network which was detailed in ten parts, 3) the role of the school network which is detailed in twelve parts, 4) a board of school network committees which is detailed in twelve parts, 5) the administration of the school network which is detailed in nine parts, and 6) the mobilization of resources which is detailed in nine parts. The results showed that the school network administration of primary educational of area office was appropriate and feasible on a large scale.

In addition, Phubet and Choocheep [12] who studied a model of work-integrated learning to prepare educational administrators for Thailand, the model consisted of 8 components: principles, objectives, system, operational methods, conditions for achievements, definitions and description, evaluation and measurement, and manual of model implementation.

6. Conclusion

Based on drafting the model and manual of model implementation of a collaborative network, the author described the responsibilities of the collaborative network as a key factor in increasing the educational quality in accordance with the National Scheme of Education B.E. 2560-2579 (2017-2036) and determined that the improvement, problem solving, and development a human resource management system involving administrators, teachers, and education personnel more effectively and efficiently including promoting a collaborative network in improving the educational quality. Therefore, it is also necessarily to build a collaborative network for all levels of education.

7. Recommendations

Research recommendations as follows:

7.1 The collaborative network can be applied as a factor for all levels of education. The result has suggested that the educational administrators and school

Table 4. The verifying results of core components of the draft model and the draft manual for implementing a model of the collaborative network for promoting learning management efficiency in schools under Chiang Mai Primary Educational Service Area.

Core components of a collaborative network model	The verifying results			
	Correction		Suitability	
	Frequency	Percentage	Frequency	Percentage
1. Principles	10.75	97.73	10.00	90.91
2. Objectives	10.00	90.91	10.00	90.91
3. Model system and mechanism	10.89	98.96	10.74	97.66
4. Operational procedures	10.92	99.30	10.92	99.30
5. Model evaluation	10.80	98.18	10.80	98.18
6. Model conditions of achievement	11.00	100.00	10.88	98.86
Total average	97.51		95.97	
A draft manual				
1. Instruction	11.00	100.00	11.00	100.00
2. Introduction	10.25	93.18	9.75	88.64
3. Background knowledge	10.00	90.91	10.00	90.91
4. A model of the collaborative network	10.36	94.22	10.64	96.69
5. The process of model implementation	10.00	90.91	11.00	100.00
6. Evaluation of model implementation	10.00	90.91	10.00	90.91
7. References	10.00	90.91	9.00	81.82
Total average	93.01		92.71	

administrators who are responsible for Thai education, should share vision and mission according to collaborative network objectives to support quality education centers.

7.2 The responsible network committee, both the advisory committee and the management committee should take action for driving the educational management to brain-storm for recent problem solutions and mobilize learning resources.

7.3 All relevant sectors/agencies should inform to build the collaborative network as the determined policy and provide the meetings and seminars to monitor the policy implementation.

8. Recommendation for Further Research

8.1 There should be a study on collaborative networks for promoting learning management efficiency within qualitative (like best practice) and quantitative (like comparative in each area) design.

8.2 There should be a study on collaborative networks for promoting learning management efficiency in terms of 21st century network and digital globalization.

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Quantitative ethnobotanical study of medicinal plants used by Karen people of Wah-Theinkha village in Kawmhu Township, Myanmar

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Abstract

The objective of this study was to document on ethnomedicinal plants, which was collected from the Karen indigenous people of Wah-Theinkha village in Kawmhu Township. The information was obtained through open-ended, semi-structured interviews. This study was able to identify 43 medicinal plants taxa in 29 families used in 17 categories of diseases. Plants with the highest recorded UVs were *Vitex trifolia* L. (0.88) and *Ageratum conyzoides* (L.) L (0.86). The lowest number of UV (0.18) was *Talinum paniculatum* (Jacq.) Gaertn. The highest ICF value (1.00) was cited for Category 7 (diseases of the eye ailments). *Stachytarpheta jamaicensis* (L.) Vahl is used to antidote which showed the highest fidelity level (92%). The knowledge of using medicinal plants was significantly different based on the village location, informant educational status, gender and age. The result showed that the application of traditional medicinal plants on ailments is still widespread in the study area. Documentation of new ethnomedicinal species with their therapeutic uses will be promoted further phytochemical and pharmacological investigations and possibly lead to the development of new drugs.

Keywords: Ethnomedicinal plants, Karen indigenous, traditional medicine, Wah-Theinkha village, ailments

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1. Introduction

In Myanmar, wild plants have long been used as a source of medicine. Traditional medicine is widely practiced in Myanmar by the majority of the population either as an alternate or as a supplement to modern medicine [1].

Kawmhu Township is located in Southern Yangon District, Yangon Region, Myanmar. It is at 16°30'0"N and 96°10'0"E [2]. Wah-Theinkha is a small rural village in Kawmhu Township. The majority of village's population is Karen ethnic, and most are rice farmers. In Kawmhu Township, 42.2 per cent of the employed persons aged 15-64 are skilled agricultural, forestry and fishery workers and also the highest proportion in the village followed by 21 per cent in elementary occupations [3].

Ethnobotany is the discipline related to study of plants concerning with their traditional uses and with the management of plant resources viewed from an historical perspective [4]. In Myanmar, ethnobotany has been focused in many studies in recent times, but

the emphasis has been on medicinal properties and the subsequent financial benefits and incentive for local communities [5].

The use of traditional medicinal practices and knowledge becomes gradually decreased and less popular because of increasing popularity of modern medicines. As a consequence, traditional medicinal knowledge was in danger of extinction [6]. Therefore, the main objective of this study was to investigate the ethnomedicinal plant species and their uses in traditional therapies used by local people of the study area.

2. Materials and Methods

The study is conducted from November 2018 to December 2019 in Wah-Theinkha village, Kawmhu Township, Yangon Region. A total of 50 informants were open-ended, semi-structured interviews regarding to the utilization of plant for medicinal purposes. Taxonomic identification was done in the Botany Department, University of Yangon. The collected plants were identified by the Flora of Hong Kong [7], Flora of Java [8], Flora of Ceylon [9] and A Checklist of Trees, Shrubs, Herbs and Climbers of Myanmar [10].

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Table 1. Medicinal plants used by the Karen-ethnic groups in Kawmhu Township.

No	Plant Species and family	Vernacular name	Part used	Disease or purpose	No.of use-report	Use Value (UV)
1.	<i>Andrographis paniculata</i> Nees. Acanthaceae	Say Khar Gyii	Lf, Wh	Diabetes, cough, skin diseases, malaria, diarrhoea	37	0.74
2.	<i>Asystasia gangetica</i> (L.) T. Anderson Acanthaceae	Kyauk Kwe	Lf, Wh	Nephrolithiasis, hemoptysis, urinary lithiasis	29	0.58
3.	<i>Barleria cristata</i> L. Acanthaceae	Leik tha ywe	Lf, Wh	Abscess, inflammation, toothache, diabetes, knee pain	23	0.46
4.	<i>Achyranthes aspera</i> L. Amaranthaceae	Khwe-nakhaung cheik	Wh, Lf, Rz	Indigestion, headache, abscess, fever	28	0.56
5.	<i>Bouea oppositifolia</i> (Roxb.) Adelb. Anacardiaceae	Ma Yan	Ft	Dysentery	25	0.5
6.	<i>Dregea volubilis</i> (L.f.) Benth. ex Hook.f Apocynaceae	Gwe Tauk	Lf	Rheumatic pain, skin wound	22	0.44
7.	<i>Aristolochia indica</i> L. Aristolochiaceae	Eik thara muli	Sd, Lf	Cancer, ulcer, tumor, antitoxin	12	0.24
8.	<i>Haplophragma adenophylla</i> (Wall. Ex G. Don) Steenis Bignoniaceae	Phet Than	Ft, St, Bk	Dysentery, muscular tension, demulcent, scabies	22	0.44
9.	<i>Oroxylum indicum</i> (L.) Kurz. Bignoniaceae	Kyaungsha	Ft, Lf, Wh, Bk, Fr	Tinnitus, asthma, inflammation	27	0.54
10.	<i>Heliotropium indicum</i> L. Boraginaceae	Sin hna - maung	Wh	Nephrolithiasis, polyuria, urinary lithiasis, kidney disease, cancer	25	0.50
11.	<i>Cleome ruidosperma</i> DC. Cleomaceae	Taw Hin - Galar	Wh, Ft	Constipation, asthma, diarrhoea	30	0.6
12.	<i>Ageratum conyzoides</i> (L.) L. Compositae	Kwe thay pan	Lf, Wh	Cough, fever, asthma, wounds	43	0.86
13.	<i>Chromolaena odorata</i> (L.) R.M. King. & H. Rob. Compositae	Taw Bi sat	Lf	Skin wound, eye pain, cancer, wound, tuberculosis, asthma, cough	29	0.58
14.	<i>Eclipta prostrata</i> (L.) L. Compositae	Kyeik Man	Lf, Wh, Ft	Menstrual disorders, skin burn, skin diseases, scar, cut, hair black	40	0.80
15.	<i>Elephantopus mollis</i> Kunth. Compositae	Kyar mote sate	Lf, Wh	Hypotension, diarrhoea	24	0.48
16.	<i>Euphorbia tithymaloides</i> L. Euphorbiaceae	Gong Ga Man	Lf	Wounds, abscess, blister, boil	38	0.76
17.	<i>Clerodendrum indicum</i> (L.) Kuntze Lamiaceae	NgaYant Padu	Lf, Fr, Rt	Diabetic, dysentery, tumor, hypertension, earache, Hepatitis, gonorrhea, influenza	33	0.66
18.	<i>Ocimum americanum</i> L. Lamiaceae	Pin sein	Lf, Sd	Poison, snake bite, scabies, cough	20	0.40
19.	<i>Vitex trifolia</i> L. Lamiaceae	Kyaung pan	Lf, Wh	Fever, child fever, asthma, dysentery, cough, abscess	44	0.88
20.	<i>Mimosa pudica</i> L. Leguminosae	Htika yon	Wh	Diaphoretic, pile	31	0.62
21.	<i>Mucuna pruriens</i> (L.) DC. Leguminosae	Khwe layar	Sd	Tonic, cancer, sleepiness, heart disease, diabetes, hypertension, poison, antitoxin	29	0.58
22.	<i>Tadehagi triquetrum</i> (L.) H. Ohashi Leguminosae	LaukThay	Lf, Wh, Rz	Antiseptic, itch, nephrolithiasis, tuberculosis, hepatitis, lung cancer	27	0.54
23.	<i>Magnolia grandiflora</i> L. Magnoliaceae	Ta Daing Mwe	Rt, Fr, Bk	Abscess, diaphoretic, itch, sore	14	0.28
24.	<i>Corchorus olitorius</i> L. Malvaceae	Pi law Yine	Lf	Arthritis, nerve pain, knee cover, dysentery, fever	28	0.56
25.	<i>Maranta arundinacea</i> L. Marantaceae	Thin	Rt, St	Antidote, piles	19	0.38
26.	<i>Syzygium jambos</i> (L.) Alston Myrtaceae	Thakyar Thi	Ft, Lf	Fever	26	0.52
27.	<i>Averrhoa carambola</i> L. Oxalidaceae	Zaung layar	Ft	Hypertension, dizzy, urinary lithiasis, itch	36	0.72
28.	<i>Pandanus amaryllifolius</i> Roxb. Pandanaceae	Swan Hmwe	Lf	Fever, skin disease	20	0.4
29.	<i>Phyllanthus chamaepeuce</i> Ridl. Phyllanthaceae	Taung Zee Phyu	Wh, Lf, Rt	Cough, hepatitis, cardiac disease, heart diseases, kidney diseases	31	0.62
30.	<i>Phyllanthu semblica</i> L. Phyllanthaceae	Taw zee phyu	Ft	Heart diseases, diabetes, constipation, menstrual disease, cancer, stomachic	22	0.44

Table 1. (cont.) Medicinal plants used by the Karen-ethnic groups in Kawmhu Township.

No	Plant Species and family	Vernacular name	Part used	Disease or purpose	No. of use-report	Use Value (UV)
31.	<i>Sauropus androgynous</i> (L.) Merr. Phyllanthaceae	Kyet Tha Hinn	Lf, Wh	Cough, hepatitis-B, hepatitis-C	30	0.6
32.	<i>Peperomia pellucida</i> (L.) Piperaceae	Thit yay Gyii pin	Wh, Lf	Cataract, cancer, breast cancer	31	0.62
33.	<i>Piper nigrum</i> L. Piperaceae	Nga yoke Kaung	Sd, Lf, Ft	Fever, toothache, diarrhoea, cough	34	0.68
34.	<i>Scoparia dulcis</i> L. Plantaginaceae	Dana thu kha	Wh, Lf	Toothache, asthma, cough	26	0.52
35.	<i>Cymbopogon citratus</i> (DC.) Stapf. Poaceae	Sa balin	Lf, St, Rz	Arthritic joints, boils	27	0.54
36.	<i>Polygonum tomentosum</i> Willd. Polygonaceae	Ma Har Karkyan Sit	Wh, Lf	Arthritis, edema, poisonous, wounds, constipation	27	0.54
37.	<i>Solanum indicum</i> L. Solanaceae	Khayan kazaw	Ft, Lf	Hypertension, fever, gonorrhea, menstrual disorders	27	0.54
38.	<i>Physalis minima</i> L. Solanaceae	Bauk Thi	Lf, Ft	Cystitis, wound, hypertension, inflammation, purgative	22	0.44
39.	<i>Talinum paniculatum</i> (Jacq.) Gaertn. Talinaceae	Ginn Sin	Rt	Diabetes	9	0.18
40.	<i>Stachytarpheta jamaicensis</i> (L.) Verbenaceae	A seik ta yar	Lf, Wh	Snake bite, scorpion bite, antidote, antitoxin	32	0.64
41.	<i>Cissus quadrangularis</i> L. Vitaceae	Shazaung let set	Wh, Lf	Broken bone, dislocate, cancer	29	0.58
42.	<i>Curcuma longa</i> L. Zingiberaceae	Na nwin	Rz, Lf, Rt	Rheumatism, dysentery, wounds, headaches, diarrhoea, stomachaches, skin care	41	0.82
43.	<i>Hedychium gracile</i> Roxb. Zingiberaceae	Padè Kaw	Rz, Ft, St	Dysentery, diarrhea, stomach	26	0.52

*Remark Rt: Root, Ft: Fruit, Lf: leaf, Wh: Whole Plant, Bk: bark, St: stem, Rz: Rhizome, Sd: seed, Yst: Young stem.

Quantitatively, the ethnobotanical data were analyzed by Use Value (UV) [11, 12], Informant consensus factor (ICF) [13] and Fidelity (FL %) [14].

3. Results and Discussion

3.1 Ethnomedicinal plants and the parts

The present investigation dealt with 43 species of ethnomedicinal plants belonging to 29 families (Table 1). The highest numbers of the recorded ethnomedicinal plants were from the Compositae (four species) followed by the Leguminosae and Acanthaceae (three species each) then the Euphorbiaceae, Zingiberaceae, Solanaceae, Verbenaceae, Bignoniaceae, Piperaceae and Lamiaceae which having two species each. Most of these families were used for edible and medicinal plants. However, most of the plants from these 29 families are documented that these plants contained active constituents and processed as qualified traditional medicine. Of all recorded species, herbs (26 species) were found to account for the greatest number followed by trees (10 species), climber (4 species) and shrubs (3 species).

3.2 Quantitative analysis

3.2.1 Use report

A total of 1200 use reports have been documented in this study which is categorized in seventeen different ailments (Table 2). These include disease of gastrointestinal illness aliment totally 216 use reports from 39

taxa which is the highest number record. It is therefore noted that the gastrointestinal illness aliment is the highest category in Myanmar [15].

3.2.2 Use value (UV)

The results of the use value of 43 plant species revealed that *Vitex trifolia* L. has the highest number of use report (44) and UV (0.88). The second highest number of use report (43) and UV (0.86) were *Ageratum conyzoides* (L.) L. The decoction of whole plants and leaves of *V. trifolia* L. is used to treat fever, asthma, dysentery, cough and abscess. Water from boiling the leaves is ingested for weakness and weight loss, malaria, menstrual problems, and conditions related to birthing, as well as for coughs and colds in infants and young children. *V. trifolia* L. dry leaf powder consumed orally for body swollen and tinnitus, decoction of flowers leaves consumed orally for malaria [16]. The fresh juice and decoction of *A. conyzoides* L. leave used to treat cough, fever, asthma and wound. The cold infusion of *A. conyzoides* (L.) L. leaves used to wash sore. Serves as an antiseptic for skin diseases and leprosy [16, 17]

The lowest number of use report (9) and UV (0.18) was obtained from *Talinum paniculatum* (Jacq.) Gaertn. (Table 1). The decoction of root of *T. paniculatum* (Jacq.) Gaertn is used to treat diabetes. The medicinal plant species with low UV are also very important and should not be ignored as failing to declare them to upcoming generations which could raise

Table 2. Categories Informant Consensus Factor (ICF) ailment categories.

Sr. no.	Ailment Categories	Number of use report (N_{ur})	Number of taxa (N_t)	Informant Consensus Factor (ICF)
1	Gastrointestinal ailments	216	39	0.82
2	Respiratory ailments	123	22	0.82
3	Fever ailments	125	17	0.87
4	Tumor ailments	46	11	0.77
5	Diabetes ailments	33	7	0.86
6	Migraine ailments	40	4	0.92
7	Eye ailments	6	1	1
8	Ear ailments	23	2	0.95
9	Blood pressure ailments	38	8	0.81
10	Dermatological ailments	91	17	0.82
11	Muscular skeletal ailments	63	9	0.87
12	Urinary genital tract infection ailments	196	24	0.88
13	Poisonous bites ailments	76	9	0.89
14	Injury cause by external factors ailments	48	13	0.74
15	Liver ailments	22	6	0.76
16	Heart ailments	9	3	0.75
17	Other general	45	9	0.81
Total		1200	201	

Table 3. Most frequently used plants for different ailment categories based on highest FL (%) in each ailment category (Total informants = 50).

No.	Botanical name	Ailment categories	Citation for particular disease (use report)	Fidelity level (%)
1	<i>Stachytarpheta ajamaicensis</i> (L.) Vahl	Antidote	46	92
2	<i>Eclipta prostrata</i> (L.) L.	Menstrual disorder	45	90
3	<i>Euphorbia tithymaloides</i> L.	Wound	44	88
4	<i>Curcuma longa</i> (L.)	Diarrhea	42	84
5	<i>Ageratum conyzoides</i> (L.) L.	Cough	42	84
6	<i>Barleria cristata</i> L.	Dizzy	40	80
7	<i>Peperomia pellucida</i> (L.)	Cataract	37	74
8	<i>Dregea volubilis</i> (L.f.) Benth. ex Hook. f	Arthritis	37	74
9	<i>Andrographis paniculata</i> Nees.	Diabetes	36	72
10	<i>Vitex trifolia</i> L.	Fever	34	68
11	<i>Chromolaena odorata</i> (L.) R.M. King. H. Rob.	Wound	33	66
12	<i>Piper nigrum</i> L.	Fever	32	64
13	<i>Tadehagi triquetrum</i> (L.) H. Ohashi	Antiseptic	30	60
14	<i>Clerodendrum indicum</i> (L.) Kuntz	Carminative	30	60
15	<i>Phyllanthus chamaepeuce</i> Ridl.	Diuretic	29	58
16	<i>Sauropus androgynous</i> (L.) Merr.	Diuretic	25	50

the threat of slowly vanishing of the knowledge [18]. However, the plant species having high UV should be further screened in ethnopharmacological studies for active compounds [19].

3.3 Informant consensus factor (ICF)

The Informant Consensus Factor ICF values ranges from as low as 0.74 to as high as 1 in the present findings (Table 2). The results of this study showed that the highest ICF value (1) is for the diseases of the eye ailment (eye pain). It is recorded that only one species, *Chromolaena odorata* (L.) was cited to treat the eye pain by the informants. The reasons were the greater consensus on the use of a given plants to treat a particular ailment category, the availability of this medicinal plants from wild habitats nearby and inheriting traditional medicinal knowledge for eye pain from their ancestors. In India the leaf is used to treat dysentery; also applied on fresh cuts and wounds to stop bleeding [13]. An aqueous ethanol extract of the leaves of *C. odorata* were found to have antifungal activity [20]. The next highest ICF value (0.95) *Oroxylum indicum* (L.) was for the disease category for tinnitus in this study. One reported revealed that the leaf juice of *O. indicum* was used as a remedy for opium toxicity. Leaves are also boiled and eaten to stimulate bowel movements. In the Philippines the juice from the crushed bark is rubbed on the back to relieve the

ache accompanying malaria [20]. *Clerodendrum indicum* L. was the most commonly used plant species for earache disease category. However, the decoction of all parts of plants consumed orally for body swollen and urinary diseases [17].

Higher the value of ICF (close to 1) means that the higher the degree of agreement between the informants and the selected taxa to be used in treatment within a category of ailments while low ICF represents disagreement among the informants [21]. High ICF values also indicated that the species are traditionally used to treat these ailments which are worth searching for bioactive compounds. The low ICF value as recorded in this study did not mean that the plant species has no worth value and it could be due to a lack of communication among people in the study areas.

3.4 Fidelity level (FL)

From the results, the highest FL values were observed in *Stachytarpheta jamaicensis* (L.) Vahl (92%) used in antidote and *Eclipta prostrata* (L.) L. (90%) used in menstrual disorder. *Sauropus androgynous* (L.) Merr. was the plant with the lowest FL value (50%) which used to treat diuretic (Table 3). Plants that have higher number of FL value are considered to be the model plants that can be employed in further ethno-pharmacological research [22]. Among

16 species, most species contain flavonoids, tannins, saponins, steroids, alkaloids and glycosides. But the major bioactive components in *Sauropus androgynous* (L.) Merr. are the fatty acids, flavonoids, and polyphenols [23]. However, *Stachytarpheta jamaicensis* (L.) Vahl have therapeutic properties.

4. Conclusion

Myanmar has rich in plant diversity. The present study showed that traditional treatment systems using medicinal plants is still prevalent in the studied areas. The analyzed data may provide opportunities for extraction of new bioactive constituents and to develop herbal remedies. The study also confirmed that the communities residing in the area have not struggled for conservation of this traditional treasure of indigenous knowledge and medicinal plants. Therefore, conservation strategies should be adopted for the protection of medicinal plants and traditional knowledge in the study area to sustain them in the future.

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An optimal deposit-refund system for mitigating hazardous packaging waste in Thailand's agricultural sector

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Abstract

This study utilized a Deposit-Refund System (DRS) with an optimal rate of deposit in order to increase the return rate of hazardous chemical packaging waste back into the system. Both survey and time series data were used to examine the willingness to pay (WTP) of Thai farmers and the marginal social cost of waste disposal (MSC) so that they would be used as an appropriate deposit rate. The findings indicate that using MSC at 0.30 USD/bottle as deposit rate would induce a higher return rate than using WTP at 0.15 USD/bottle. The distance between farmers' homes and hazardous chemical shops can also negatively affect the return rate. Thus, to reduce hazardous packaging waste in Thai agriculture, the government needs to impose a deposit rate at 0.30 USD/bottle (MSC) and strategically increase the number of returning points in order to boost the return rate for hazardous packaging waste.

Keywords: deposit-refund system, hazardous packaging waste, agriculture, pesticides, herbicides

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1. Introduction

The industrial and agricultural sectors are two major sources of hazardous waste in Thailand. While industrial waste is controlled by Thailand's Department of Industrial Works, in the agricultural sector there is no clear responsibility for hazardous waste. This may have caused an increase in the amount of hazardous waste from the agricultural sector by +5.73% in 2014, whereas the waste from industrial sector decreased by -23.23% in the same year [1]. As there is no specific regulation for handling hazardous waste from agricultural production, Thai farmers would use chemicals and throw away the packages, e.g. plastic and glass bottles. Consequently, they might get injured from the hazardous packaging wastes. The report of the Pollution Control Department, Thailand [2] states that from 2003 to 2010 the number of Thai residents who were injured or died due to agricultural hazardous waste were about 13,389 persons while the industrial hazardous waste caused injury or die for just 2,625 persons. This phenomenon should therefore be reconsidered as a severe problem in Thai agriculture. In addition, there were many kinds of hazardous chemicals used in Thai agricultural production in order to protect products at every stage, but the main hazardous chemicals used were herbicides, followed by pesticides. The uses of herbicide and pesticide substances accounted for more than 90% of all kinds of chemicals in the sector [1]. Hence, it is crucial to deploy some policies to

manage the waste in the agricultural sector to prevent the number of people getting injured or dying due to hazardous wastes from agricultural production which is growing continuously.

To deal with this issue, it is necessary to employ a suitable economic instrument combined with a command and control policy as suggested by Tietenberg [3] and Oates and Baumol [4]. They claimed that using only a command and control policy may not achieve an economic efficiency because of the high long-term costs of monitoring. However, the economic instrument that is suitable for the case must meet the goals of environmental effectiveness, economic efficiency, equity, administrative cost-effectiveness, and acceptability [5]. There are five groups of economic instruments which could be considered in this case 1) Tax, Fee, and Charge 2) Tradable Permit System 3) Deposit-Refund System 4) Subsidy and 5) Green Procurement [6, 7]. These groups of economic instruments can be used for managing waste in different circumstances. For example, Tax, Fee, and Charge may change consumer behaviors of waste generation [8] but they may distort market price mechanisms as well. The Tradable Permit System could influence producers to invent green technologies but the cost of implementation is rather higher than other tools. The Deposit-Refund System could effectively reduce the amount of waste, especially packaging waste, but it may not work for some cases. The Subsidy tool would be better for encouraging consumers to reduce their waste but it needs a long period

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of promotion and may be ineffective with the society which has a high rate of population movement. The last tool, Green Procurement, was not found suitable for handling the waste problem as it focuses on the upstream process of production rather than the waste products [6].

Moreover, numerous studies have compared those economic tools which should be used for managing wastes in particular packaging wastes. For instance, Fullerton and Wolverton [9, 10] showed that with general equilibrium analysis, the Deposit-Refund System could be easier to implement than the Pigouvian tax and it could also create better waste contribution awareness at household level than the tax. This was confirmed by the study of Palmer and Walls [11]. They stated that if policy makers use the Deposit-Refund System with an equal rate among deposit rate, refund rate and marginal social cost, the social benefit would be larger than using just a tax or subsidy alone. Palmer and Sigman [12] and Walls [13] also compared the implementation costs across Tax, Subsidy, and Deposit-Refund System tools for waste management by using the Monte Carlo technique. Their key result was that the Deposit-Refund System could generate less implementation costs than others and it could decrease recyclable waste by 7.5%. Like Palmer and Sigman [12], Walls [13], and Oosterhuis et al. [14] investigated the effectiveness of a Deposit-Refund System compared to the tax. They found that the Deposit-Refund System could better decrease the amount of marine litter, as the revenue from tax may be used for other purposes and not only for waste management.

Many of the studies mentioned above concluded that the Deposit-Refund System was the most effective tool for packaging waste management as it could reduce waste significantly and the cost of implementation was not remarkably high like others. These findings were confirmed by Walls [13], Fullerton and Wolverton [10], and Fullerton and Wolverton [15] who stated that, according to their theoretical and empirical analysis, the Deposit-Refund System was more suitable for packaging waste management than using virgin material tax, disposal fee, or recycled content standard. That is why many countries in the world implement a Deposit-Refund System as their main policy for container waste management as can be seen in Table 1 [6]. The table illustrates that the Deposit-Refund System was deployed mainly in order to manage containers of both alcoholic and non-alcoholic drinks. The rate of deposit was between 0.05 – 0.78 USD. These deposit rates were used for can and glass containers mainly. However, Kursah and Baabereyir [16] showed that the willingness to pay of people in Ghana for a deposit of sachet water plastic bag was just 0.013 USD (40% of the production cost per unit). It is true that the plastic bag is cheap. Thus, people tend to pay less for its deposit but this may lead to unredeemed deposit as well.

On the one hand, a Deposit-Refund System was a popular tool for packaging waste management in many countries and its effectiveness was affirmed by the study of Lavee [17]. He studied costs and benefits of implementing the Deposit-Refund System to handle beverage containers in Israel. The findings indicated that the benefits from the policy such as lower waste management cost were greater than the cost of the policy implementation by over 35%. On the other hand, the deposit-refund may not be suitable for every case, as claimed by Numata [18]. His findings showed that the deposit-refund may have negative impacts on some stakeholders and these impacts had not been taken into consideration; for instance, some consumers may not return their container waste to the sellers and leave their deposit. Consequently, the process of the Deposit-Refund System is not completed which in turn induces an inefficiency policy. The use of a Deposit-Refund System in the used oil industries in the USA was a good case in point as well. It was found that the cost-effectiveness ratio (the proportion between the transaction cost of implementing a Deposit-Refund System and the amount of waste being returned) was high due to an inconvenient waste return process. Thus, the transaction cost was getting high and became a barrier for the waste management to succeed [19].

On the whole, it is evident that a Deposit-Refund System was used in many countries due to its efficiency of getting waste back into the system. Most of them implemented the policy to manage consumer goods waste rather than hazardous waste even though hazardous waste would be more dangerous. In addition, due to the critical issue of hazardous packaging waste management in the Thai agricultural sector, an implementation of Deposit-Refund System policy seems to be viable. Hence, this study investigated the use of a Deposit-Refund System in Thai agricultural sector in order to get hazardous packaging waste back into the system while other previous studies would focus on drink containers and consumer goods waste mainly. In this paper, an optimal rate of deposit-refund was examined so that the system could achieve a high return rate of hazardous packaging waste in Thai agriculture by utilizing both survey data and time series data. These data were collected in Songkhla province which was selected as a representative province in Thailand.

Songkhla as a major province in the south of Thailand had been ranked as a top province producing waste in 2013. It used to account for 2.5 million tons of waste and people living in Songkhla could generate waste for 1.8 kilograms per person [1]. Even though the local governor attempted to reduce the enormous amount of waste, it seems not good enough as Songkhla was still in the top ten list of provinces generating waste in Thailand in 2018 [20]. In addition, the majority of people here are rubber and rice farmers

Table 1. The implementation of deposit refund systems in various countries.

Country	System	Containers Covered	Deposit
Austria	Law to make deposit regulatory	PET bottles (non-refillables excluded)	\$0.4
Denmark	Packaging Law	Beer and soft drinks containers, Deposits on some wine and spirit bottles	\$0.27 – \$0.78
Netherlands	Agreement deposit	Soft drinks and water in one-way and refillable glass and PET containers	\$0.16 – \$0.72
Norway	Deposit on containers and tax dependent on return rate	Most drinks excluding milk, vegetable juices and water	\$0.16 – \$0.40
South Africa	Deposit return system	Approx. 75% beer, 45% soft drinks and some wine and spirits bottles	8 – 15% of product cost
Sweden	Law requires rate of 90% recycling of aluminium cans, or complete ban	Aluminium cans and PET	\$0.07 – \$0.56
Switzerland	Deposits required on all refillable drinks containers	All refillable drinks containers	\$0.16 – \$0.40
South Australia	Container Deposit Legislation- deposit required on almost all drinks containers	Most included except wine (unless in plastic bottle), milk, pure fruit juice	\$0.10 – \$0.05
USA-California	California Beverage Container Recycling and Litter Reduction Act	Non-refillable drinks containers, e.g. beer, spirits, carbonated, fruit drinks and some vegetable juices	\$0.05 – \$0.10
USA-Vermont	Beverage Container Law Deposit-return system	Beer, soft drinks, malt, soda and mineral water, mixed wine and liquor	0.05–0.15

Source: modified from Hogg et al. [6]

and supply their productions to many factories in the area. It is undeniable that rubber and rice productions need to use hazardous chemical such as herbicide and pesticide substances. The report of Pollution Control Department [1] also showed that there were many people getting injured or dying due to hazardous wastes from agricultural production in the province. That is why this study chose Songkhla province as proxy area of interest. However, it is the fact that the main hazardous chemicals used in Songkhla province were in a form of bottle due to the convenience of using and handling so this paper would investigate an optimal rate of deposit-refund as the first priority rather than the other forms of hazardous packaging.

Thus, the data obtained in the province were analyzed in order to discover an optimal deposit rate. As a result, the rate of injury and death due to toxicity of hazardous packaging waste in the Thai agricultural sector especially Songkhla province would decrease and ecological systems would be protected from toxic substances left over in the hazardous chemical packages used in agricultural production.

2. Methodology

To investigate a suitable deposit rate that could attract Thai farmers to return their hazardous packaging, the study needs to compare the returning probabilities between using the willingness to pay (WTP) expressed by the farmers and using marginal social cost (MSC) as suggested by Palmer and Walls [11]. They found that the optimal deposit rate should be equal to the marginal social cost of disposal as it could lead to a social optimum. However, their research would base on theoretical work and consumer goods mainly. For this reason, the methodology of examining the suitable deposit rate begins with exploring the two option rates of the deposit: 1) the willingness of Thai farmers to pay (WTP) and 2) the marginal social cost (MSC) of disposal. Consequently, the probabilities of hazardous packaging being returned under the two rates of deposit were computed and compared in order to reveal

the best option for Thai farmers.

2.1 An analysis of WTP as a first candidate of an optimal deposit rate

To obtain WTP, a questionnaire was used as the main instrument. It was divided into three main parts. The first part was about general information of Thai farmers such as gender, age, and chemical use in production. The second was designed to ask about the farmers' WTP for the hazardous packaging deposit. The last part was devoted to evaluate the damages of hazardous packaging waste. The questionnaire was then proved for validity and reliability before collecting data. After that, four hundred respondents were interviewed by using both quota and accidental sampling techniques. Each respondent was face to face interviewed by the author at their home as each question needs to be clarified and ensured especially for getting the WTP and the environmental damages. This procedure was started in October 2018 and kept going until four hundred respondents were completely collected in March 2019. Regarding the part two in the questionnaire, before the price that farmers are willing to pay for deposit was asked, the impacts of hazardous chemical packaging waste were presented to the farmers first followed by the concept of a Deposit-Refund System which the government plans to implement in order to get hazardous packaging waste back into the system. After that, the farmers were then asked for an acceptable price of the packaging deposit. The answer was then filled in the questionnaire by the interviewer.

The part three in the questionnaire was designed to express damages of hazardous packaging waste. The damages were classified into two main sides: health damage and environmental damage. The former was measured by capturing the cost of illness caused by hazardous chemical which was left over its package including the cost of transportation from their home to a hospital. The latter was evaluated by using the contingent valuation method (CVM). The CVM is one of useful valuation techniques which could express the individuals' value for environmental goods un-

der stated preferences. Survey questions were used to elicit preferences of respondents directly, by asking the individuals to state their preferences for the environmental goods [21]. As a result, the environmental value could be revealed through a pseudo market based on the story and questions in questionnaires which consists of three main parts: 1) a detailed description of the environmental goods 2) questions which are used to elicit the price for the goods and 3) questions about characteristics of respondents as they can be used to estimate a valuation function of the environmental goods.

In addition, an ecology system which was devastated by hazardous packaging waste has to be valued by the farmer so the survey question was designed by following suggestions of Zainudin et al. [22]. They recommended that the first paragraph of the question should introduce environmental goods in general. The second should explain the details of goods that the respondents need to evaluate and the last part should come with the details of how the goods will be provided and the method that will be used to pay for the goods. Thus, the interviewer explained the damages of hazardous packaging waste on an ecology system by showing them the picture and asked the farmers to mitigate such damages by paying their money through the helping program of the municipality. The program will be introduced in a form of charging fee per bottle of hazardous chemical use as this method of paying would be accessible for all farmers. After they answered the most WTP for the fee as a free form, the iterative bidding technique was then used to negotiate what is the rate should be, like the study of Zainudin et al. [22]. This process was carried on until the respondent does not change their answer anymore. As a result, the ecology system damage was identified and filled in the questionnaire by the interviewer.

To sum up, it is obvious that the WTP as a candidate of an optimal deposit rate could be obtained from the answer in the part two of a questionnaire so that it would be utilized to calculate the probability of hazardous packaging waste being returned in section 2.3. The rest of survey data such as damage evaluation would then be used to compute the marginal externality cost of waste management in section 2.2.

2.2 An analysis of MSC as a second candidate of an optimal deposit rate

According to an analysis of MSC, Palmer and Walls [11] had claimed that the function of packaging waste disposal would be in a form of Cobb-Douglas because the disposal process could be seen as a production process. Thus, the hazardous packaging waste disposal function was formed as follows;

$$Z = A^\alpha K^\beta L^{1-\alpha-\beta} \quad (1)$$

where Z is the amount of hazardous packaging waste in a process of waste disposal. A is technological level.

K is capital endowments. L is the amount of labour working in the process. α, β are coefficients and $0 < \alpha, \beta < 1$.

Moreover, the social cost of waste disposal (SC) is equal to the summation of the total cost (TC) and the externality cost of waste management (EC). The total cost consists of the fixed cost (FC) and the variable cost (VC). Hence, equations 2 and 3 were constructed.

$$SC = TC + EC \quad (2)$$

$$SC = FC + VC + EC \quad (3)$$

where FC is defined as an exogenous cost dependent on the product of capital endowments (K) and their returns (r). VC is defined as a product of wage (ω) and labours which is dependent on the hazardous packaging waste disposal function ($F(Z)$). EC is also dependent on the hazardous packaging waste disposal function ($EC(Z)$). Consequently, the social cost function was formed as follows;

$$SC = rK + \omega L(Z) + EC(Z) \quad (4)$$

The first order condition of this function with respect to the amount of packaging waste was then calculated. Thus, the marginal social cost (MSC) was revealed as shown in equation 5.

$$MSC = \omega ML_Z + MEC_Z \quad (5)$$

where ML_Z is the marginal labour cost with respect to waste and MEC_Z is the marginal externality cost with respect to waste.

The marginal labour cost of hazardous packaging waste here was indicated by regressing the labour cost data provided by the Songkhla municipal office [23]. First of all, an explicit form of the relation between labour costs and packaging wastes was identified by comparing across all 3 main forms: linear, log-linear, and double-log linear forms. As a result, the labour cost coefficient from the most explainable function could be extracted and used as a marginal labour cost of hazardous packaging waste. Moreover, the marginal externality cost could be computed by employing the data surveyed in Songkhla province as mentioned above. The damages induced by hazardous packaging waste were evaluated by using either market price technique or CVM technique. They were classified into two main types of damages, namely health and environmental damages. Both of these damages were then used as externality costs of hazardous packaging waste. The relation between externality costs and the amount of hazardous packaging waste was then revealed in order to extract the marginal effect of the waste. As the marginal labour and the marginal externality were indicated, the marginal social cost could be calculated as expressed in equation 5.

2.3 The probability of hazardous packaging waste being returned

Due to Numata's study [24], DRS may lead to market inefficiency even though it is better than other economic tools. The reason for this is that the farmers would have a lack of incentive to return their hazardous packaging waste as their opportunity cost is higher than the deposit. Hence, this study took this concern into consideration by comparing the probabilities of return packaging waste between using WTP and MSC as a deposit rate. The probabilities were calculated by using a binomial logistic regression technique as the outcomes of farmer's decision can be only returned (1) and not returned (0). Thus, let $\Pr(y = 1)$ represents the probability of the waste being returned and $\Pr(y = 0)$ represents the probability of the waste not being returned. The explanation factors here were the farmer's revenue per day (REV), the number of household members that are not over 11 years old ($CHILD$), and the distance between their house and the hazardous chemical shop that kept their deposit ($DIST$). Regarding this relation, equation 6 was created.

$$\ln\left(\frac{\Pr(y = 1)}{\Pr(y = 0)}\right) = y_i = c + \beta_{1i}REV + \beta_{2i}CHILD + \beta_{3i}DIST \quad (6)$$

where y is a logarithm of the ratio between the probability that farmers return packaging waste and the probability that farmers do not return packaging waste. $\beta_1, \beta_2, \beta_3$ are coefficients of $REV, CHILD$ and $DIST$ factors, respectively. $i = 1$ represents the case of using WTP as a deposit rate and $i = 2$ represents the case of using MSC as a deposit rate.

3. Results and Discussion

The data used to indicate both WTP and MEC for this study were obtained from 400 farmers in Songkhla province, Thailand. In general, the proportion between male and female were not significantly different. They were 48 years old on average and had been educated to just primary school level. The main characteristics of samples looked similar to general information of Songkhla population shown in the Songkhla municipality annual report 2016 [23]. From this information, it is evident that the samples in this study could be good representatives of farmers in Songkhla province. However, the samples were then interviewed in detail. The findings presented that most sample households consisted of four members including one less than 11 years old child. The farmers used at least one bottle of hazardous chemical per month in their production. Some of them would walk or ride a bicycle to buy hazardous chemicals but the majority of them preferred to take a motorcycle or car instead. The average distance from a farmer's house to a hazardous chemical shop was 5.7 kilometers, so the

farmers would spend about 15 minutes for transportation. In addition, they evaluated damage values from the hazardous chemical as well. They expressed that the impact on their health and the environment were about 42.93 USD/bottle and 0.42 USD/bottle, respectively. Thus, the total damage value estimated by each farmer was about 43.35 USD/bottle as shown in Tables 2.

As the farmers were asked about the deposit rate, they would be willing to pay, many rates were indicated. However, the most favoured rate was 0.15 USD/bottle as this figure accounted for over 50% of the farmers (Table 3). The reason for this was that they tried to compare it with the price of used bottles in a waste market. Thus, this study would take the rate of deposit as 0.15 USD/bottle in the case of WTP rate. Consequently, the farmer had to choose between returning and not returning their packaging wastes under the case of using WTP as a deposit rate.

According to MSC described in equation 5, this study had to investigate the marginal labour cost with respect to waste (ML_Z) and the marginal externality cost with respect to waste (MEC_Z). To obtain ML_Z , the time series of labour expenditure paid for waste management in Songkhla were obtained [23]. The data were monthly collected from 2010 to 2016. They consisted of both fulltime and temporary labour cost which depended on the expected amount of waste in each month. Then, they were analyzed with a regression technique as follows.

First of all, the suitable form of the relation between the labour cost and the amount of waste had to be defined. From Table 4, it is clear that the simple linear form has nonstationary because the Dickey-Fuller unit-root test results show that we cannot reject the null hypothesis of nonstationary in the linear form of time series. In fact, a time series is stationary if its mean and variance are constant over time. Thus, the stationary in time series data is a crucial assumption in order to estimate parameters [25]. If this assumption is broken, the results of estimation would lead to other problems such as inconsistent of estimation, autocorrelation, and spurious correlation [26]. For this reason, the linear form should not be considered due to time series analysis ground rules. Hence, the comparison between the semi-log form and the double-log form indicated that the semi-log form performed better than the other in terms of either R^2 or AIC/BIC. It means that the semi-log function could explain the labour cost variable for 66.39% which was higher than the double-log form. In the meantime, AIC and BIC are criteria to choose a better model. The lower AIC/BIC represent the better model as it would close to the true model. For this study, the AIC/BIC values of the semi-log model were lower than the double-log model so the estimation of labour cost given by the semi-log model would be closer to the true value than the double-log. The test results also showed that there

Table 2. General information of Thai farmers in Songkhla province.

Variable	Mean	Std. Dev.	Min	Max
Age (years)	48.298	11.884	17	86
Household members (persons)	4.2625	1.629	1	12
Children below the age of 11 (persons)	0.645	0.892	0	4
Rubber production capability (kg./day)	35.353	88.548	3	1,536
Revenue (baht/day)	549.343	521.56	60	5,600
Round-trip distances from home to shop (km.)	5.799	10.404	0.2	100
Round-trip times from home to shop (minutes)	15.303	14.884	1	120
Health damage value (USD/bottle)	42.932	38.357	8.690	217.860
Environmental damage value (USD/bottle)	0.415	0.255	0.150	1.500
Total damage value (USD/bottle)	43.347	38.613	8.840	219.360

Table 3. The willingness to pay for the hazardous packaging deposit.

WTP (USD/bottle)	Freq.	%
0.030	15	3.75
0.060	14	3.5
0.090	24	6
0.120	19	4.75
0.150	218	54.5
0.180	36	9
0.210	14	3.5
0.240	18	4.5
0.300	38	9.5
More than 0.300	4	1
Total	400	100

was no issue about multicollinearity, autocorrelation, heteroskedasticity, as well as unit root.

Thus, the semi-log linear form was utilized in order to examine the marginal labour cost of waste disposal. As a result, the effect of waste on the labour cost was written as followed;

$$\ln(\text{LabourCost}) = 11.21 + 0.00012\text{Waste} \quad (7)$$

Then, equation 7 was transformed by using natural logarithm properties as $e \approx 2.71828183$ so equation 8 was constructed.

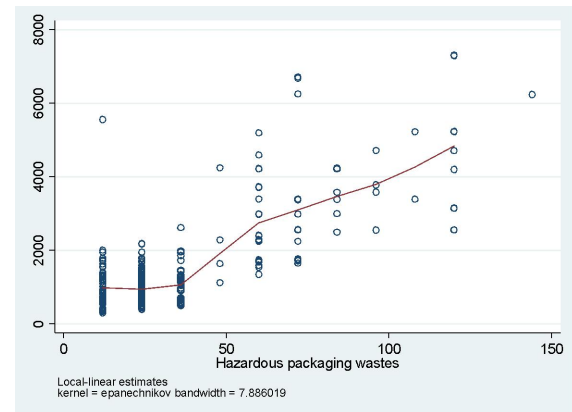
$$\text{LabourCost} = 73,865.42 + e^{0.00012\text{Waste}} \quad (8)$$

To obtain the marginal labour cost with respect to waste (ML_Z), it needs to calculate the derivatives of equation 8 with respect to waste as shown below;

$$ML_Z = 0.00012e^{0.00012\text{Waste}} \quad (9)$$

Equation 9 shows that the marginal labour cost with respect to waste (ML_Z) would depend on the product of 0.00012 and $e^{(0.00012\text{waste})}$. Thus, ML_Z could be calculated and combined with the MEC_Z which was determined in the next section, in order to compute MSC at the end.

The next step was devoted to identify MEC_Z by exploring the damage value from surveyed data. However, as the linear regression technique under parametric analysis assumes that each disturbance (u_i) has normal distribution [25], the normality tests such as Skewness and kurtosis test and Shapiro-Wilk and Shapiro-Francia tests have been used to test the distribution of the disturbances resulted in damages and waste regression. The both normality test results showed that the p-values were 0.0000 which were less

**Figure 1:** Relation of waste and damage cost with a nonparametric estimated plot.

than the significance level at 0.05. Thus, we can reject the hypothesis that the disturbance is normally distributed so the data cannot be analyzed with a parametric analysis [27, 28]. Hence, this study used a nonparametric analysis as a main technique to estimate an effect of waste on the total damage cost. The aim of the nonparametric estimation techniques is to estimate models with as fewest functional form and distribution assumptions as possible [29]. This study utilized kernel nonparametric regression as it is popular in literatures. This technique was introduced by Nadaraya [30] and Watson [31]. Then, there were many studies which extended the idea and enlarged the techniques of nonparametric analysis such as Ullah and Vinod [32] and Ullah [33]. Kernel nonparametric regression focuses on density estimation and/or distribution functions directly by smoothing the variables. It can be seen as an extension of Weighted Least Squares (WLS) which aim to minimize a weighted residual sum of squares. This is different from an Ordinary Least Squares (OLS) technique used in parametric analysis as OLS makes no distinction of where the data are located when estimating the conditional expectation. In contrast, kernel nonparametric regression will estimate the point of interest using data within a bandwidth instead [34].

In addition, as the major advantage of nonparametric regression is that it does not require Gauss-Markov assumptions including normal distribution assumption to be held, Kernel nonparametric regression was obtained to estimate the effect of waste on the total dam-

Table 4. Regression results from various forms of the relations between LabourCost and Waste.

Variable/Test method	Linear	Semi-Log	Double-Log
	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)
Constant	-43486.2 (43344.67)	11.2049* (0.172884)	6.979237* (1.674714)
Waste	26.3429* (10.68732)	0.00012* (4.26E-05)	0.566783* (0.203354)
R ²	0.6815	0.6639	0.6634
Adj. R ²	0.6721	0.654	0.6535
AIC	1716.691	-48.66328	-48.55737
BIC	1723.479	-41.87524	-41.76933
DF Unit Root Test of LabourCost (H ₀ : no stationary)	0.1216	0.0328*	0.0328*
DF Unit Root Test of Waste (H ₀ : no stationary)	0.0000*	0.0000*	0.0000*
Durbin test for autocorrelation (H ₀ : no serial correlation)	0.7732	0.4957	0.4570
Breusch-Godfrey test (H ₀ : no serial correlation)	0.7669	0.4846	0.4458
B-P / C-W test for heteroskedasticity (H ₀ : Constant variance)	0.3988	0.9991	1.0000

*denotes significance at 1%

Table 5. Effect of wastes on damage cost estimated by nonparametric regression.

DamageCost	Estimate	Std.Err.	P > z
Mean of DamageCost	43.402	2.416	0.000
Effect of Wastes	0.287	0.136	0.035

Table 6. Binomial logistic regression results for the case of using WTP as a deposit rate.

WTP(0.15 USD/bottle)	Coef.	Std.Err.	z	P > z
Constant	2.464854	0.246657	9.99	0.000*
Revenue	0.000434	0.00012	3.60	0.000*
Children below the age of 11	-0.45861	0.160047	-2.87	0.004*
Distance	-0.46768	0.067162	-6.96	0.000*
Pseudo R ² = 0.4058				

* significance at 1%

age cost here. The nonparametric regression results in Table 5 indicated that the effect of waste on the damage cost was 0.29 at a significance level of 0.05. It means that the damage cost (health and environmental impact costs) would increase 0.29 USD when the amount of waste increases for 1 bottle of hazardous packaging waste. This figure can be seen as a marginal externality cost (MEC_Z) of throwing 1 hazardous packaging waste out of the proper system. As a result, Figure 1 was then plotted to illustrate the estimated damage values upon hazardous waste by using nonparametric regression technique.

Regarding ML_Z and MEC_Z mentioned above, the marginal social cost of waste disposal was computed by replacing both values in equation 5 with an average wage at 306 USD/month [34] so that MSC was about 0.30 USD/bottle. Thus, this study would take this rate as a deposit rate for the case of using MSC. Up to here, both rates of deposit were defined already. The case of using WTP, the deposit rate was 0.15 USD/bottle and in the case of using MSC, the deposit rate was 0.30 USD/bottle. It is important to note that the rate of 0.15 USD/bottle was close to the rate used in Europe countries such as Netherlands, Norway and Switzerland but this rate may not be suitable for hazardous packaging waste. As such rate was set for consumer good waste

Table 7. Binomial logistic regression results for the case of using MSC as a deposit rate.

MSC(0.30 USD/bottle)	Coef.	Std.Err.	z	P > z
Constant	3.217235	0.408022	7.88	0.000*
Revenue	0.003271	0.000586	5.58	0.000*
Children below the age of 11	0.123533	0.309467	0.4	0.690
Distance	-0.34535	0.043636	-7.91	0.000*
Pseudo R ² = 0.659				

* significance at 1%

Table 8. Predicted probabilities for hazardous packaging waste return using WTP and MSC, respectively.

Variable	Mean of probabilities	Std. Dev.	Min	Max
WTP (0.15 USD)	0.6650	0.323300	2.74E-19	1
MSC (0.30 USD)	0.8575	0.291541	3.26E-09	1

deposit mainly, the countries do not need to take impacts on human health and environment into consideration before setting the deposit rate. This would be a different point of looking at hazardous packaging waste which could impact on both human and environment. For this reason, the suitable rate should induce a higher rate of waste being returned. Hence, these two rates were used to estimate the probabilities of return hazardous packaging wastes for both scenarios. A binomial logistic regression was employed as a main tool to illustrate the factors influencing the probability of return and predict the probability of return as well.

Tables 6 and 7 present the effects of three main factors: revenue, numbers of children below the age of 11, and distance from home to hazardous chemical shop in the cases of using WTP and MSC as a deposit rate, respectively. It is evident that all main factors could affect the probability of return in the case of using WTP. In fact, the distance and the number of children would have negative impacts on the probability as the cost of return would get higher than the deposit rate when farmers have to go further and spend more time in order to get a deposit back from the shop. In contrast, if their revenue gets higher, they would tend to return more. This would be interpreted that the

revenue could increase farmers' ability to return hazardous packaging waste as they could afford for the cost of transportation and administrative activities. As in the case of using WTP, if the government imposes MSC as a deposit rate, distance and revenue would have a major impact on probability of return with the same direction. But the number of children could not impact on the probability in this case.

Both scenarios affirm that the distance between the farmer's house and the hazardous chemical shop play an important role for the returning probability of Thai farmers. Consequently, the returning probabilities of each farmer for both cases of deposit rates: WTP and MSC were computed by using estimated results in Table 6 for the case of WTP and Table 7 for the case of MSC. Thus, Table 8 was therefore created to present the predicted probabilities of hazardous packaging waste return under the two scenarios. The figures show that using MSC (0.30 USD/bottle) as a deposit rate could increase the returning probability to 86%, averagely while using WTP (0.15 USD/bottle) could create the probability of just 67%, averagely. For this reason, the government should use the MSC as a deposit rate when it is going to impose the Deposit-Refund System in the Thai agricultural sector, reducing unredeemed deposits by establishing an optimal deposit rate. The farmers would tend to return their hazardous packaging waste, and subsequently, the number of injuries and deaths related to hazardous packaging waste would decrease substantially.

4. Conclusions

It is clear that the Deposit-Refund System (DRS) is an efficient economic tool to cope with waste, especially beverage container and packaging waste, as many countries in the world have shown. However, it appears to be a rare case of applying DRS in the agricultural sector. This study aimed to study a suitable DRS in order to reduce hazardous chemical packaging waste in Thai agriculture, as Thai farmers continue to use the chemicals in their production but do not take responsibility for their waste. Thus, there is a risk of Thai people being injured or dying due to such hazardous waste. The deposit rate is still the key issue for the case as it may lead to an inefficient policy due to a high non-return rate [18]. This study utilized two different rates of deposit: the willingness to pay for a packaging deposit (WTP) and the marginal social cost (MSC) suggested by Palmer and Walls [11]. The findings indicated that using MSC as a deposit rate could better incentivize Thai farmers to return their waste than using WTP as expressed by Thai farmers. This was relevant to the study of Siritorn and Permpoonwiwat [35]. They found that WTP for a waste collection service could not lead to an optimal price as people tend to express it lower than the true one due to extra living cost awareness. That's why the probability of

returning waste in the case of using WTP as a deposit rate was lower than using MSC, remarkably. Apart from the fact that MSC as a deposit rate could draw the hazardous packaging waste back into the system better than using WTP as a deposit, the distance between farmers' homes and agricultural chemical shops also has significantly a negative impact on the returning rate as well.

For these reasons, the government of Thailand should consider DRS as a main policy of managing hazardous packaging waste especially in the agricultural sector. The policy implementation is also one of important parts. The government should set the rate of deposit to be equal to MSC rate (0.30 USD/bottle) and increase the number of returning points in order to reduce the opportunity cost of Thai farmers. As a result, the number of people getting injured or dying due to hazardous wastes from agricultural production would be reduced soon.

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Marketing mix factors affecting the frequency and loyalty in online transactions of Nakhon Pathom teenagers

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Abstract

This research is aimed at 1. To compare the frequency and loyalty in online transactions of Nakhon Pathom teenagers when classified by personal factors and 2. To study the influence of marketing mix factors affecting the frequency and loyalty in online transactions of Nakhon Pathom teenagers. The researchers collected data from a sample of 400 teenagers interested in buying and doing online transactions in Nakhon Pathom Province by snowball sampling. The statistics used in the research were frequency, percentage, mean, standard deviation, T-test, one-way variance analysis and multiple regression analysis.

The findings of the research are as follows. (1) The frequency and loyalty in online transactions of Nakhon Pathom teenagers were different when classified by gender, age, education and income with statistical significance. (2) The marketing mix factors affecting the frequency of online transactions of Nakhon Pathom teenagers comprised the price ($b = 0.21$), distribution promotion ($b = 0.16$) and product ($b = 0.15$). The equation has a predictive power equal to 41 percent. This can be written as follows: $Y = 1.46 + 0.15X_1^{**} + 0.21X_2^{**} + 0.03X_3 + 0.16X_4^{**}$ (3) The marketing mix factors affecting loyalty in online transactions of Nakhon Pathom teenagers consisted of the product ($b = 0.45$), price ($b = 0.30$) and distribution promotion ($b = 0.13$). The equation has a predictive power equal to 44 percent. This can be written as follows: $Y = 1.85 + 0.45X_1^{**} + 0.30X_2^{**} + 0.01X_3 + 0.13X_4^{**}$

Keywords: Marketing mix, loyalty, online transactions

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1. Introduction

Online trading plays a role and is very important nowadays because of convenient and fast trading. [1] The online world is like a meeting and trading point that meets the needs of consumers the most today. Obviously, the groups of manufacturers, merchants, including retailers or wholesalers use the online channel to distribute the products to consumers because this channel can expand the customer base more than before. Therefore, at present, it is found that the transactions in selling goods and recommending the products can be done online with no limitations on the type of product. The traders do not need a storefront. Meanwhile, the buyers just want to purchase goods. Despite not going to purchase by oneself, the online channel is able to meet the needs easily by simply clicking and choosing to buy the products, thus causing the trend of continuously higher competition in this business.

In the past, for many types of businesses, especially buying-selling businesses, the business owners always needed a storefront or a shop fixed to market for finding customers, including marketing plans as well as new ideas about publicity for serving and offering to customers. However, for modern times with

much technological progress, the internet network has a greater role in communication. As a result, this whole world is able to be connected together through the Internet network. So, there are inventors who can operate businesses by using the Internet network as a medium just by having the Internet inside the house and starting a business [2].

The opening of online stores is currently remarkable. There are online restaurants, online candy shops, clothing shops and even general goods stores. Many online shops are further developments of the original business base so as to provide convenience to customers. Also, this marketing method is not expensive and can last for a long time. Doing online business will not look difficult, but the competition is very high because many new stores will open in the online world daily. [3] The Internet network currently covers all areas. It is possible to click at home so as to buy the desired products and have goods delivered to the home without wasting time going to buy. As a result, many people are interested in buying products through the Internet network. The largest consumer group will be teenagers because the teenagers behavior doing online transactions tends to easily change decision-making to buy. The teenagers are active in using online media. However, due to limited money,

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Table 1. Average, marketing mix factors, frequency of transactions per week and loyalty in transactions overall.

Marketing mix	Mean	S.D.	Level
Product	4.20	0.35	High
Price	4.20	0.49	High
Distribution channel	4.05	0.58	High
Promotion	4.14	0.51	High
Loyalty in transactions	4.01	0.28	High
Frequency of transactions	2.86	11.25	

the teenagers are likely to be disloyal to when deciding to buy the products. [4] Therefore, the attempts to find the right marketing mix for stimulating the frequency of buying and building loyalty are essential as Aaker [5] proposed the importance of loyalty as an expression of consumers who insist on buying the same products and do not change their mind to buy the goods of new brands.

Consequently, the research team was interested in studying the marketing mix factors affecting the frequency and loyalty in online transactions of Nakhon Pathom teenagers. The researchers have hoped that the results of this study will be useful for online business operators so that information from this research will be used to develop marketing strategies to suit the needs of such consumer groups or that the people interested in investing in this business will use the information from this study as guidelines or a tool for helping to decide on investments, work management and strategic planning for doing business later.

Research objectives

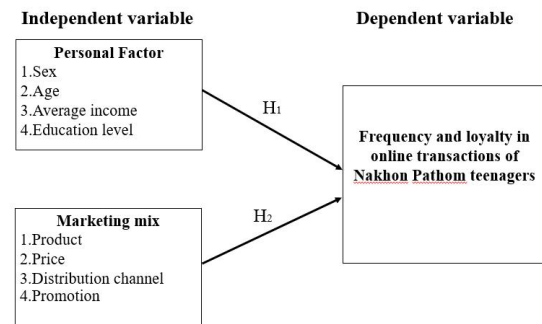
1. To compare the frequency and loyalty in online transactions of Nakhon Pathom teenagers when classified by personal factors.
2. To study the influence of marketing mix factors affecting the frequency and loyalty in online transactions of Nakhon Pathom teenagers.

Hypotheses in the study

1. The frequency and loyalty in online transactions of Nakhon Pathom teenagers are different when classified by personal factors.
2. The marketing mix factors affect the frequency and loyalty in online transactions of Nakhon Pathom teenagers.

2. Related Documents and Research

The researchers used the concepts and theories related to marketing mix [6, 17]; consumer behavior [7, 8], loyalty-related concepts [9 – 12] and electronic marketing [1, 13, 14, 18, 19] for development into research framework. The details are shown in Figure 1.

**Figure 1:** Research framework.

3. Research Methodology

3.1 Sample population

The population used in this research were the teenagers interested in buying and doing online transactions in Nakhon Pathom Province. Because no true numeric data collection has been found yet, the researchers used the determination of sample size without the known population by Cochern's formula [15] resulting in the sample size of 385 persons. The researchers increased the sample size to 400 persons by means of Snow ball sampling.

3.2 Research tool

The Questionnaire was created by the researchers that tested the content validity and tested the reliability by Cronbach's alpha coefficient with 30 Ramkhamhaeng University students, resulting in the validity of 0.74 – 0.88.

3.3 Data analysis

As to data analysis in this research, information from the questionnaire was processed by means of data analysis with frequency, percentage, mean, standard deviation, T-test, one-way variance analysis and multiple regression analysis.

4. Research Results

The research results comprise the results of analyzing descriptive statistics and reference summary statistics as follows.

4.1 According to research results based on personal factors of the respondents, the majority were male, accounting for 58.75 percent. Most of them were aged between 19 – 21 years, representing 69.25 percent, mostly graduated with a bachelor's degree, accounting for 75.50 percent. The majority had incomes lower than 12,000 baht per month, equivalent to 52.00 percent.

4.2 Results of analyzing the average, marketing mix factors, frequency of transactions per week and loyalty in online transactions of Nakhon Pathom teenagers.

Table 2. Results of testing the hypothesis 1: Frequency and loyalty in online transactions of Nakhon Pathom teenagers are different when classified by personal factors.

	Gender	Age	Education	Income
Frequency of transactions	-2.23**	88.44**	67.10**	91.54**
Loyalty in transactions	5.35**	36.77**	18.84**	20.87**

Table 3. Results of testing the hypothesis No. 2.1: Marketing mix factors affecting the frequency of online transactions of Nakhon Pathom teenagers.

	B	SE	Beta	t	Sig
(Constant)	1.46	0.33		4.41	0.00
Product X ₁	0.15	0.05	0.15	2.92**	0.00
Price X ₂	0.21	0.04	0.30	5.31**	0.00
Distribution channel X ₃	0.03	0.03	0.05	0.93	0.36
Promotion X ₄	0.16	0.03	0.24	4.89**	0.00

R₂ = 0.41

According to Table 1, the overall marketing mix factors were at the high level. When considering each individual aspect, it was found that the product and the price were Mean = 4.20, followed by the marketing promotion (Mean = 4.14) and distribution channel (Mean = 4.05), respectively. As to dependent variables, the frequency of transactions per week was found to be at 2.86 times per week and loyalty in transactions was at the high level (Mean = 4.01).

According to research results, the frequency per week of online transactions of Nakhon Pathom teenagers varied according to gender, age, education and income.

Loyalty in online transactions of Nakhon Pathom teenagers varied according to gender, age, education and income.

According to the research results, the marketing mix factors affecting the frequency of online transactions of Nakhon Pathom teenagers comprised the price ($b = 0.21$), distribution promotion ($b = 0.16$) and product ($b = 0.15$). The equation has a predictive power equal to 41 percent.

This can be written as follows $Y = 1.46 + 0.15X_1^{**} + 0.21X_2^{**} + 0.03X_3 + 0.16X_4^{**}$.

According to the research results, the marketing mix factors affecting loyalty in online transactions of Nakhon Pathom teenagers consisted of the product ($b = 0.45$), price ($b = 0.30$) and distribution promotion ($b = 0.13$). The equation has a predictive power equal to 44 percent.

This can be written as follows: $Y = 1.85 + 0.45X_1^{**} + 0.30X_2^{**} + 0.01X_3 + 0.13X_4^{**}$.

5. Conclusion, Discussion of the Results and Recommendations

5.1 Conclusion and discussion of the results

1. According to research results, the frequency of online transactions of teenagers per week and loyalty in online transactions of Nakhon Pathom teenagers when classified by personal factors were consistent

with the research of Chantawiwuttikul [16] who studied the behavior of group purchasing of goods and online services on ENSOGO website of customers in Bangkok Metropolis. The research results showed that different demographic characteristics of consumers will vary in behavior of group purchasing of goods and online services on ENSOGO website in a statistically significant manner.

2. The marketing mix factors affected the frequency of transactions per week and loyalty in online transactions of Nakhon Pathom teenagers in terms of product, price and distribution promotion. Such research results revealed that the use of marketing mix is still necessary for online transactions. This was consistent with the research of Watthanakun [8] who studied the factors related to buying behavior of consumers through Thailand's popular electronic commerce website. The research results proposed that the marketing mix affects the creation of website components and causes relationships with the consumers buying behavior via the electronic commerce website of customers.

5.2 Suggestions for use in this research

1. Interesting findings revealed that the highest frequency of online transactions per week of Nakhon Pathom teenagers was the female aged between 22 – 24 years, who graduated with a bachelor's degree and earned 15,001 – 18,000 baht per month. Meanwhile, the highest loyalty in transactions was the male aged between 19 – 21 years, who graduated with a bachelor's degree and earned 12,001 – 15,000 baht per month. This shows some differences of consumers. That is to say, in terms of frequency of online transactions, the females' frequency of access was higher than the males. However, the males' loyalty, no change of access to services was higher. Meanwhile, the persons aged 22 – 24 years had the highest frequency of transactions. Loyalty was the group aged 19 – 21 years. The incomes with the frequency of transactions were 15,001 – 18,000 baht per month. The loyalty group consisted of people with incomes

Table 4. Results of testing the hypothesis No. 2.2: Marketing mix factors affecting loyalty in online transactions of Nakhon Pathom teenagers.

	B	SE	Beta	t	Sig
(Constant)	1.85	0.35		5.28	0.00
Product X ₁	0.45	0.06	0.41	8.11**	0.00
Price X ₂	0.30	0.04	0.39	7.16**	0.00
Distribution channel X ₃	0.01	0.03	0.02	0.37	0.71
Promotion X ₄	0.13	0.04	0.17	3.54**	0.00

R₂ = 0.44

of 12,001 – 15,000 baht. Such differences are likely to be the results that enable the operators to focus on the correct target groups so as to boost sales in online transactions of teenagers in the future.

2. The use of marketing mix factors affecting the frequency of online transactions of Nakhon Pathom teenagers was comprised of the price, distribution promotion and product. The marketing mix factors affecting loyalty in online transactions of Nakhon Pathom teenagers was comprised of the product, price and distribution promotion. From the research, it was found that the distribution channel factor did not affect the frequency and loyalty in transactions because online transactions had not yet made a difference in the feelings of teenage consumers. The highlights of online transactions depend on three marketing mix factors by building loyalty with need to focus on the products because good products will make a good impression and cause repeated purchases. Meanwhile, creating the buying frequency will focus on the price factor because the price factor will cause the buying decisions to be faster and more frequent. Therefore, people who do online transactions must decide to focus on the marketing mix factors classified by consumer behavior.

5.3 Suggestions for further research

1. This research limited the study area to teenagers in Nakhon Pathom Province only. Interested people may extend to other consumer groups and the boundaries in other provinces so as to get a wider range of discoveries.

2. The conceptual framework of other academics should be used in order to compare and use the study results as guidelines for developing the studies on such topics later.

3. This research is a cross- section study during the given period only. Interested persons may conduct research in the form of time series so as to compare the differences in each period.

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Win-win or not? Factors impacting Chinese programs in Thai higher education under zero-game

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Abstract

Chinese Programs, initiated by Thai Higher Education Institutes (HEI) in the context of the “One Belt and One Road” Initiative (BRI) proposed by Chinese President Xi Jinping in 2013, have been absorbing the increasing mobility of Chinese international students to help Thailand transit to the regional education hub. This paper applies mixed methods approaches to explore the characteristics of Chinese programs as follows: To know the global international market by documenting data collecting such as qualitative research, to analyze the macro environment both inside and outside of Thailand; To inspect the key factors on Chinese programs management by questionnaire data analysis of Chinese students’ satisfaction in Thailand as quantitative research. The results indicate this multi-stakeholder program is the effective approach to leverage both the inbound and outbound, public and private resources benefiting the mutual higher education cooperation between Thailand and China with rising marginal effect. This study unveils that 67% of Chinese international students are satisfied, and that there are 17 key factors affecting Chinese Programs operating on selecting Thai HEIs, Educating Process and Supporting Sectors to improve their satisfaction as a win-win deal.

Keywords: Chinese programs, Thai Higher Education Institute, regional education cooperation

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1. Introduction

China’s decades of opening up to foreign trade and investment as well as implementing free-market reforms since 1979 has not only greatly improved the livelihood of the Chinese people but also changed the global market and trend as the world second largest economy [1]. Thus, the study abroad and international student’s mobility have no exception.

UNESCO’s Asia-Pacific regional bureau for education in Bangkok noticed that the International Mobility of Students in Asia and the Pacific are increasing, and Global flow of Tertiary-level students are mainly Chinese international students; meanwhile, its report also unveiled that compared to the traditional students’ host countries in major English-Speaking countries, regional hubs play a more and more important role of attracting international students, especially the students from border areas or neighboring countries. The mobility of Chinese students stimulates local economies a lot (UNESCO, 2013)[2]. University of Oxford also emphasized that almost one in six international students of the global market is Chinese (Oxford, 2015)[3].

Thailand has been becoming a more favorable destination for Chinese students in continuing education and furthering their study. They have become the major source of foreign students in Thailand since 2006.

In 2012, there were 9,329 Chinese students to be found in Thai HEIs (46.4% of total foreign student population) (Hongzhi, Athapol, and Chenin, 2015)[4]. As the first foreign direct investor since China’s Opening up and in the context of BRI, Charoen Pokphand (CP) Group’s affiliated Panyapiwat Institute of Management (PIM) grafted its international programs with Chinese language instruction oriented to Chinese students in 2013 and greatly inspired followers among various Thai HEIs.

Due to the significant transition on the biographical side of Thai society, such as population aging and decreased fertility, more seats in Thai universities are spared to the international students, especially Chinese students who constantly occupies the lion’s share of global market. Chinese programs become the main drive to attract mobility from China by Thai HEIs.

Consecutively, Chinese programs are flourishing on Thai campuses and wooing Chinese tertiary education certificate or diploma pursuers. The Education Office of the Chinese Embassy in Thailand witnessed this great increase of Chinese mobility with an estimated 50,000 Chinese students before 2020 and define the Chinese Program as programs or schools that involve textbooks or teaching activities in the Chinese language and may accept Chinese students, including but are not confined to all-Chinese programs, Thai-Chinese programs, English-Chinese programs, and Thai-English-Chinese trilingual programs in all

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Thai HEIs[5].

2. Literature Review

2.1 Global international student market as zero-game

Traditionally, the destinations of Northern countries, such as the United States and the United Kingdom remain strong magnets for international students seeking a high-quality education while new destinations from Southern countries and recent regional hubs are competing for a share of the mobility revenue and formed the zero-game as in and out. Based on a long term observation, UNESCO found the factors driving the growth and expansion in undergraduate and graduate education across Asia are key actors of regional international mobility, international program quality evaluation, strength and productivity in international collaboration, and opportunities for education policy makers (UNESCO, 2014)[6].

It indicated that international student mobility could follow this trend on two sides; the traditional global education centers and the emerging regional education hubs. The former remains strong on the abilities of English instructed education on traditional advantages, but the latter flourishes with potential and possibilities of knowing well on neighboring needs. However, it is still a gradual process for the emerging countries to achieve the ambitious goals and make the global international student market in tough competition. Many cooperated or collaborated higher educational programs are starting to result in more dramatic changes on the global international student's mobility and trend.

3. Research Objective

This research aimed to:

1. Study the situations of the Chinese program in Thai higher education and its satisfaction from Chinese international students.
2. Explore the key factors to develop the Chinese program as a successful tertiary educational program mutually benefiting Thailand and China.

3.1 Regional education hub as strategy to boost the economy

The conception of "Education Hub" was initiated by Malaysian Ministry of Education in an official policy document named Wawasan 2020 (Vision 2020) which dates back to 1990 and aims to develop Malaysia as "a world-class quality education which is flexible and innovative that in turn will make Malaysia a regional educational hub and a centre of educational excellence." [7]

One of the most important marginal effect phenomena is that many governments noticed the importance of public universities and the fast-emerging private

universities as the centers of education and research to yield positive economic returns to their country[6]. Meanwhile, short distance, better education, comparable costs are becoming the key factors for regional education hubs to attract the nearby international students and the advantage to compete with traditional destinations under the unstable and uncertain circumstances such as Brexit of UK [8], Trumponomics from USA[9], and racism in Australia[10]; China's Ministry of Education even consecutively for two years announced the NO. 1 Alarm of Study abroad on the high risk of COVID-19 and racism in Australia on June 9th of 2020[11] and February 5th of 2021[12] respectively.

4. Conceptual Framework

As the Chinese program in Thai HEIs specially orients itself to the Chinese international students and becomes the main drive to attract the Chinese mobility, this research conducts the survey on those students. Their satisfaction comes mainly from 21 indicators in the educational process inspecting the relationship by Pearson Chi-Square's analysis to sort out the key factors both inside and outside the Chinese Program.

5. Research Methodology

5.1 Research instrumentation and questionnaire design

This survey is divided into two parts to explore both the descriptive and statistical data as follows: Part I consists of demographic data of respondents and a rationale on selecting Thai HEIs: The first 8 basic information questions are descriptive statistics to unveil the respondent's name of their university, name of their program, primary residence (province) in China, average monthly expenses in Thailand, gender, program category, channels to know Thai HEIs, and their rationale to study in Thailand. Part II mainly focuses on internal indicators on the Education process and Supporting Sectors from the Chinese program: The following 9 to 25 choices marked by the scoring of the questionnaire will be analyzed by using a five-point rating scale or five-Likert scales (5 Very Satisfied, 4 Satisfied, 3 General, 2 Dissatisfied, 1 Very Dissatisfied)[13] are covered 16 internal indicators of Chinese Program including: General satisfaction, Quality, Facility, Management, Curricula, Instruction, Discussion & Communication, Equipment, Teaching Avenue, Library, Accommodation, Recreation (Sports & Fitness), Canteen or Dining, Location & Transportation, Academic & Research level, Teaching Planning & Organizing, and Assessment & Evaluation; which uses Pearson Product Moment Correlation Coefficient analysis to explore the relationship among student's satisfaction and other 20 variables (16 indicators plus

Table 1. Chinese students' satisfaction on study in Thai HEIs from 2016 to 2019 (n=468).

Symbols	Predictor Variables	Very Satisfied	Satisfied	General	Dissatisfied	Strongly Dissatisfied
9	General Impression	10.3%	58.1%	22.0%	8.1%	1.5%
10	Quality	8.5%	60.5%	19.4%	10.3%	1.3%
11	Facility	12.6%	59.8%	15.0%	10.5%	2.1%
12	Management	8.1%	56.8%	23.1%	10.3%	1.7%
13	Curricula	6.2%	54.7%	21.4%	15.6%	2.1%
14	Teacher's Instruction	12.4%	61.1%	17.7%	7.3%	1.5%
15	Discussion & Communication	12.0%	63.3%	15.0%	7.9%	1.8%
16	Classroom	13.5%	63.6%	15.0%	6.4%	1.5%
17	Teaching Venue	13.5%	62.6%	13.2%	8.8%	1.9%
18	Library	21.8%	46.4%	21.6%	7.6%	2.6%
19	Accommodation	9.7%	43.3%	23.5%	17.5%	6.0%
20	Recreation & Fitness Center	10.6%	53.2%	19.4%	13.6%	3.2%
21	Canteen or Dining	9.2%	43.6%	23.4%	18.2%	5.6%
22	Location & Transportation	10.3%	50.9%	21.2%	14.3%	3.4%
23	Academic & Research level	11.1%	49.8%	33.5%	4.3%	1.3%
24	Planning & Organizing	9.6%	57.3%	23.3%	8.3%	1.5%
25	Assessment & Evaluation	9.2%	58.3%	25.2%	6.2%	1.1%
MEAN	Total Average Satisfaction	11%	56%	21%	10%	2%

previous 4 basic indicators as Gender, Program category, Channels to know Thai HEIs and Rationale to study in Thailand) to explore the key factors.

5.2 Population and sample

The population of Chinese students involved into various Chinese programs are no more than 50,000 until 2019 [5], calculated by Yamane Formula [14]:

Where, $N(\text{population size}) = 50,000$ people
 $e(\text{error of 5 percentage points}) = \text{error allowed 5 percent} = 0.05$

$n(\text{sample size}) = 50,000 / (1 + 50,000 \times e^2) = 396.82$
 $53968253968 \approx 397$

Thus, the random sampling size should be larger than 397.

5.3 Data collection

In this study, 1470 questionnaires were distributed to 89 universities from the recommendation-list-of-Thai-universities from the Ministry of Education in China which lasted from 13 November 2016 to 9 December 2019 and touched all types of Chinese programs, such as exchange student, undergraduate, post-graduate, "3+1" or "2+2" students, etc.

468 respondents from 52 Thai HEIs (more than 66% are from Private Universities) were successfully and fully received which is a larger scale than the sample size of 397; which means valid to analyze.

The researcher collected data from 468 valid respondents to sort out Chinese students' satisfaction of studying in Thailand and followed the procedure of data input and analysis through the package software (SPSS: Statistical Package for Social Sciences) to unveil the significant indicators affecting their satisfaction, which also became the key factors of operating the Chinese Programs in Thailand.

6. Interpreting the Results

6.1 Satisfaction from Chinese students of Chinese programs in Thai Higher Education

The 17 Predictor Variables covered the major elements among the hardware, software and education process of Chinese programs provided by Thai HEIs; and the student's response to these variables are obvious indicators that imply the overall satisfaction from Chinese students and the efficacy of Chinese Programs.

The outcome of the survey unveils that 67% of Chinese students are satisfied with their studies in Thailand, whereas 21% neutral and 12% unsatisfied. This indicates that Chinese programs are greatly catering to Chinese international students at large. On the Educational hardware, Thai universities should be proud of their Library, teaching facilities and equipment, and Sports and Fitness Centers, which are highly catering to the needs of the Chinese students. On the academic level, small group and international instruction style are popular to the Chinese students, especially during the discussion and communication session; and the scheduled planned teaching process was also appreciated. Otherwise, the accommodation, canteen and dining with more than 20% dissatisfaction should be improved according to the varied demands from the supporting sectors.

Chinese students' satisfaction vividly demonstrates that a good study environment, specialized Curricula, and international instruction style with delicate management are the strength of Chinese programs, while the accommodation and other supporting sectors should be diversified.

6.2 *Demographic Characteristics of Chinese students in Thailand*

6.2.1 *Gender distribution*

There are more female (302 respondents, 69.6%) than male (166 respondents, 30.4%) Chinese students with the satisfaction rate of 69% and 64% respectively without distinctions.

This detail implies the distribution is closely related to the limited disciplines offered by Chinese programs in Thai HEIs, which are mostly focusing on Thai language, Management and devoid of STEM choices for males. On the contrary, male Chinese students spend much more than female by about 4,578.72 Baht each month in an academic year. Balanced Chinese programs in disciplines could amplify this kind of marginal effect.

6.2.2 *Most mobility provided areas from China*

Yunnan Province and Guangxi Zhuang Autonomous Region from The Great Mekong Sub-region (GMS) [15] contributed 60% of the Chinese students to Thailand while the others are more or less from the other parts of mainland China; which implies that the similar historical, cultural and ideological recognition and close relationships are the steady elements to keeping the mobility provider. As the regional international city Kunming, the capital of Yunnan Province was posed as the gateway orienting South Asia and Southeast Asia, and the Sino-Thai high speed railway [16] could be accomplished by connecting Bangkok and Kunming, a potential and promising market of Chinese international students is emerging. On the other hand, the Chinese partners and stakeholders of Thai HEIs also played very important roles in attracting the local Chinese student to Thailand, especially in the populous provinces such as Sichuan, Shandong, Hubei, and Henan. Students from these areas are more difficult to gain entry into a university in mainland China, and they are more likely to choose to study abroad as alternatives if they did not do well in Gaokao, the national college entrance examination.

6.2.3 *Education Categories*

“3+1” or “2+2” Program students are the mainstream chose by Chinese students in Thai HEIs and 64% of them are satisfied. Altogether with the exchange students, there are nearly 45% non-diploma seeking Chinese students in Thailand. These kinds of students are mainly learning languages or related majors; after short learning experience in Thailand, they could be the potential applicants for the next degree at Thai universities, and they could also spread their real experience as word of mouth to impact others. On the other hand, Undergraduate and graduate fellows, and the diploma seekers of Chinese consists of 55% of the total. Obviously, Chinese Program derived from International Program with the same curricula and instruction style; but surprisingly, short-term Chinese

students are more satisfied with the study experience in Thailand.

6.2.4 *Channels to Know Thai HEIs by intermediaries*

Compared to the ordinary recruitment of international programs, Chinese programs are more reliant on their Chinese partners and stakeholders which contribute nearly 80% of Chinese mobility to Thai universities. Traditionally and historically, Chinese stakeholders are easily found in Southeast Asia [17]. Thai groups or individuals are used to doing business with Chinese back in the Sukhothai period, especially connected to the mainland China affairs; consequently, Chinese are playing roles to bridge the complexities including culture, languages, policies, etc. The overseas Chinese are serving as the connection to China and playing an important role in informal trade activities between Thailand and China [18]. The emerging Chinese programs in Thai higher education currently witness more individuals or intermediary organs to help Chinese students better know and engage with Thai universities.

6.2.5 *Rationales to study in Thailand*

Experience inclusive culture (53%), international instruction style (28.8%), comparable & reasonable tuition fees (12%) and prestigious universities (6.2%) are four main reasons for Chinese international students to choose Thai HEIs. Thailand was consecutively regarded as the least miserable country out of 66 economies for the fourth year since 2015 by Bloomberg's Misery Index [19]. As the most visited tourism destination, travelling in Thailand and enjoying Thai style leisure times during study abroad is exciting to many Chinese students. Meanwhile, Thailand holds the only world-class universities in the Indochina Peninsula or Mainland Southeast Asia [20]. Chada Triamvithaya, an academic at King Mongkut's Institute of Technology Ladkrabang (KMUTL) told Reuters that Studying for an undergraduate business degree costs up to 120,000 baht (\$3,700) a year in Thailand, while tuition fees for a similar course can range from 8,000 in Singapore to over 60,000 a year at some U.S. universities [21].

6.2.6 *Expense from Chinese students*

Normally, there are at least two semesters in one academic year, and each semester consists of at least 16 teaching weeks and 2 exam weeks, and Chinese authorities require at least 9 months' stay for overseas study each year. Meanwhile, students should register at least two 3-credit courses each semester, and it could be on average 12 credits in one academic year while each credit needs at least 7,500 Baht. On the varied accommodation, 6,000 Baht are required for monthly rent and overhead fees; and this survey demonstrates that Chinese students (n = 425, male 130, female 295) spend other average amount

Table 2. Estimated economic contribution (Baht) from one Chinese student study in Thailand for one academic year (9 months, n = 425).

Tuition	House Rent	Other Monthly Expense	Total Annual Expense
$7500 \times 12 = 90,000$	$6000 \times 9 = 54,000$	$8,918.75 \times 9 = 80,268.75$	224,268.75 (Baht)

Table 3. 17 indicators affecting satisfaction among the 21 Variables in Chinese Program (n = 468).

Symbols	Independent Variables	Dependent Variables	N	Asymp.Sig.(2-tailed)	Pearson Chi-Square
3	Province	Satisfaction	468	0.852	
5	Gender	Satisfaction	468	0.341	
6	Category**	Satisfaction	468	0.001	<0.05 Significant
7	Channel	Satisfaction	468	0.187	
8	Rationale	Satisfaction	468	0.299	
10	Quality**	Satisfaction	468	0.000	<0.05 Significant
11	Facility**	Satisfaction	468	0.000	<0.05 Significant
12	Management**	Satisfaction	468	0.000	<0.05 Significant
13	Curricula**	Satisfaction	468	0.000	<0.05 Significant
14	Teacher's Instruction**	Satisfaction	468	0.000	<0.05 Significant
15	Discussion & Communication**	Satisfaction	468	0.000	<0.05 Significant
16	Classroom**	Satisfaction	468	0.000	<0.05 Significant
17	Teaching Venue**	Satisfaction	468	0.000	<0.05 Significant
18	Library**	Satisfaction	468	0.000	<0.05 Significant
19	Accommodation**	Satisfaction	468	0.000	<0.05 Significant
20	Recreation & Fitness Center**	Satisfaction	468	0.000	<0.05 Significant
21	Canteen or Dining**	Satisfaction	468	0.000	<0.05 Significant
22	Location & Transportation**	Satisfaction	468	0.000	<0.05 Significant
23	Academic & Research level**	Satisfaction	468	0.000	<0.05 Significant
24	Planning & Organizing**	Satisfaction	468	0.000	<0.05 Significant
25	Assessment & Evaluation**	Satisfaction	468	0.000	<0.05 Significant

** p_i 0.01 (Correlation is significant at the 0.01 level (2-tailed))

to 8,918.75 each month (male 12,096.92 Baht, female 7518.20 Baht).

Therefore, as the total amount of Chinese students surpass 50,000 at the end of 2019, the Chinese student community contributes at least 11,213,437,500 Baht (= 224,268.75 × 50,000), which was the greatest contribution to Thai Higher Education and related sectors. As Chinese Programs are differentiated and specialized for Chinese students, the cost is much higher than other programs; for instance, the same kind of Programs for Thai language instruction only cost half of the Chinese program while the International Program at 70% of the cost. To Thai HEIs, that means one applicant from the Chinese program could contribute economically twice as much as the Thai students and 1.5 times the international students. This is the strong evidence that Chinese Programs, or even Specialized Chinese Colleges are emerging in Thai Higher Education and steadily freed the marginal effect in Thai society.

6.3 Correlative analysis between 21 variables of Chinese Programs and the satisfaction from Chinese students

The 21 variables inside Chinese Programs will be analyzed in form Chi-square (X²): test using categorical data analysis, Confidence level = 95%, Sig lad < 5%(0.05); If Pearson statistic < 0.05, It is a significant result; If Pearson statistic > 0.05, not significant, that means there is no strong relationship.

Sorting out the 17 key factors, they are affecting Chinese Programs operation on Selecting Thai HEIs, Educating Process and Supporting Sectors as Figure 1.

7. Conclusion

1. Chinese Programs in Thai HEIs are greatly catering to the demand from Chinese international students; the mutual needs between Chinese students and Thai HEIs are the essence of sustainability in long-term benefit as a win-win deal.

2. Program managers are key persons in the Chinese Programs. Since Program and curriculum design are vital factors to attract Chinese students, program managers are required to keep close to the needs of Chinese students so as to differentiate a marketing strategy for the future.

3. Chinese student community in Thailand, whose population is estimated to surpass 50,000 in the end of 2019, greatly contributes to the Thai economy and related sectors at least 10 billion Baht every single year; this multi-stakeholder program is the effective approach to leverage both the inbound and outbound, public and private resources benefiting the mutual higher education cooperation between Thailand and China with rising marginal effect.

4. Chinese Programs enter into the Red Sea Market. As both public and private of Thai HEIs setup

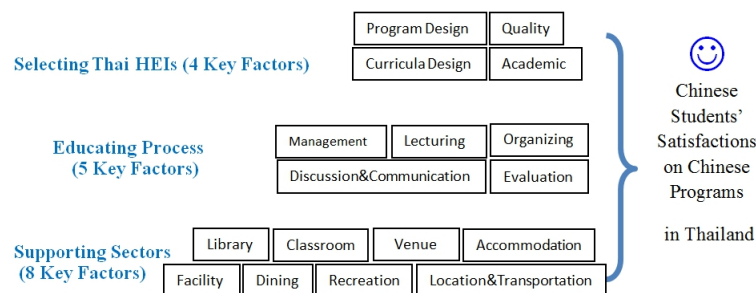


Figure 1: 17 key factors impacting Chinese programs in Thai higher education.

various Chinese programs to attract Chinese international students and compete with the traditional study abroad destinations, especially the changing policies under the outbreak of COVID-19, business in the international students market becomes a Zero-game at large.

8. Discussion

1. Chinese Program is a Win-Win Deal with Steady Returns. This kind of Program derived from the International Program with the same curricula and instruction style in quality, which is specialized to Chinese needs with 1.5 and 2 times the profit compared to the International and Thai Program respectively. Meanwhile, investment from Chinese shareholders could leverage and benefit to the higher education market in Thailand. The great contribution to the economy and relative sectors could reach more than 10 billion Baht each year. Chinese students market in Thailand could be the promising sector steadily benefited from China as the largest target market after Tourism, especially under the shock of the pandemic and economic depression.

2. Grafted and absorbed the experience of the International program, Chinese program has great potential and vitality to develop more disciplines for academic exchanges between China and Thailand in the long run.

3. Flexible and dynamic implementation of Chinese programs as a strategy could not only maintain the majority of international mobility in the changing world, but also builds Thailand as the regional education hub with competence in the global market.

4. Chinese Program is just the touchstone to display the international mobility between the regional study hub and traditional study abroad destinations which demonstrate the world trend of the global international student market at large.

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