Interdisciplinary Research Review

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Objectives of journal

1. To encourage and publish knowledge and useful opinions in any field of study
2. To support academicians and teachers in creating work beneficial to the academic community
3. To stimulate and support education at the university level

Policies of the journal :

The Interdisciplinary Research Review (IRR) publishes six issues per year. All submitted articles are subject to peer review, and must be approved by two experts in the relevant field prior to acceptance. Prior to review, all articles must pass a screening process which evaluates the articles' appropriateness for the journal, originality, proper formatting, and English proficiency. All material in each article that is not original must be properly referenced to the published literature. The editors reserve the right to modify articles in the interests of clarity and proper English usage. The opinions and views expressed in the journal are those of the authors of the respective articles and not those of the editors or publisher.

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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 15 Number 3 (May – June 2020). This issue contains of eight interesting articles in multidisciplinary fields: (1) Knowledge and practice on tuberculosis infection control among health care workers in Nay Pyi Taw, Myanmar, (2) A model of work-integrated learning to prepare educational administrators for Thailand, (3) An impact analysis of a Deposit-Refund System to mitigate hazardous packaging waste in Thai agricultural sector, (4) The development of online lessons to enhance practical skills with problem-based learning on microcontroller Arduino for undergraduate students, (5) Biological transformed cannabinoids bee pollen: A symbiosis approach on *Apis mellifera* raising protocol in *Cannabis sativa* L. (Hemp) cultivar in Samoeng District, Chiang Mai, Thailand, (6) The misuse of Tramadol among children and youth and the need for having efficient policy and laws enforcement, (7) Genetic diversity of genus *Filopaludina* in the upper northeastern Mekong Basin of Thailand revealed by mitochondrial DNA sequences, and (8) On sensitivity of control chart for monitoring serially correlated data.

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

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Yongyudh Vajaradul
Editor
Interdisciplinary Research Review

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"Do the Right Thing, Open Information as a Rule, Confidential as an Exception"

The above call was made during the speech by Mr. Suwapan Tanyuwattana who at the time of making this address was the incumbent Minister of the Prime Minister's Office. One of his many important responsibilities was to administer the Royal Society of Thailand. So when the Interdisciplinary Committee of the Royal Society of Thailand organized its 8th Interdisciplinary Research Day Conference in 2018 with the theme "Good governance of civil servants and holders of political positions", Mr. Suwapan was invited to preside over the opening ceremony and made a keynote speech. He made a call for "Doing the Right Thing" and greater attention to Good Governance, pointing out that we live in an open society so government information should also be open to all as a rule and confidential as an exception. This is in line with transparency and inviting citizen participation. The main points from this remarkable keynote speech are as follows:

Almost all Thai people know the phrase "Good Governance" which is very important for the building of our nation's past, present and future. It is in accordance with the policy of General Prayuth Chan-o-cha, Prime Minister, who wants to see Thai society as a moral and ethical society run with a merit system. The Constitution of the Kingdom of Thailand, ratified in 2017, contained many stipulations relevant to ensuring good governance and best practices. According to Article 65, "The state must ensure the existence of a national strategy towards sustainable development goals and the principles of good governance are to be used as a framework for various action plans and projects which must be consistent and integrated in order to be a driving force for national strategic goals."

Therefore, incumbent bureaucrats and politicians must govern and run the country in strict compliance with the national strategy while adhering to good governance principles. Politicians and officials within the government system will not be allowed to do whatever they feel like. They must "Do the Right Thing". Whenever in doubt about what to do ... the answer should be: Do the Right Thing because if we do the right thing in the first place, it will save a lot of troubles and in fact we don't even have to have so many laws to shape and direct people's actions. In addition, Article 76 requires that "The state should develop the administrative system both at the central government level, the local government level including rural district administration level. All must be reinforced by integrity, merit system and complete observance of good governance principles. All government agencies must cooperate and help each other in performing duties. No more obstruction or cancel each other out in the provision of public service while public budget spending should be at the highest cost efficiency and effectiveness for the benefit of the people. Government officials must be upgraded to be honest, dedicated and have service mind attitude so people experienced convenience, speed, non-discrimination and effectiveness in the performance of duties by public servants (government officials and politicians holding positions)".

As specified by the Constitution, future government has to implement at least two matters in order to upgrade the national administration's overall efficiency and effectiveness: 1) Personnel development of all government officials, state employees via a personnel management system to bring about honesty, integrity, public service mindset, solve problems effectively, without discrimination and above all to "Do the Right Thing". 2) Develop the administrative system of the country, based on a merit and moral system covering bureaucratic and justice functions so that Thailand will be known as a good and an Ethical Society based on good governance.

If our nation cannot transform these two aspects (personnel and administrative systems) into a merit system with good governance, then our chance of being regarded as an Ethical Society will be reduced. We must persevere no matter how long or how difficult the path towards our national strategic goals may be.

Thai society is to a certain degree a patronage system and seniority matters and still exerts some influence. This has its beautiful side in the Thai culture, but at the same time, we have to choose carefully and apply it correctly, and make a suitable distinction between what works and what doesn't work with regard to seniority or other aspects of patronage. The authority must give up some outdated ways of operation and be aware of the need to ensure free and fair competition and put the right man in the right job, so we have an efficient bureaucracy and effective government system at every level. In terms of personnel management and political posts we must adhere to the principles of good governance from the top level down to district and village levels. Mr. Suwapan Tanyuwattana, Minister of the Prime Minister's Office at the time of this speech, served also as chairman of the National Village and Urban Community Fund, which has 13 million members and a total of 79,000 villages. These village and community funds are good channels to convey social messages that bring about the right awareness and understanding amongst grassroots people. Here there is an opportunity to work with the National Buddhism Office and monks nationwide because the 5 Buddhist precepts (codes of conduct) are the important foundation of Ethical Society. The Royal Society, which is an amalgamation of philosophers, wise men and women of the country, can play a strong role by providing guidance and right knowledge that shapes the right mindset throughout various levels of government to do the right things in different circumstances and situations.

Returning to the Constitution Article 291 regarding the ethical standards of the Constitutional Court judges, when new laws are published in the Royal Gazette they will be enforced to all, including members of parliament (MPs), senators and cabinet ministers. Therefore, politicians must follow ethical standards of good governance such as not demanding or accepting cash, property, gifts or other items that will affect their rightful function. This ethical standard has been promulgated since 30 January 2018. Therefore, all political positions must adhere to this while civil society should play a role in the awareness campaign throughout society at large.

As the Chairman of the National Moral Promotion Committee, there is a 5-year master plan of operation. The plan is not only done by and for government officials, but is participated in by experts in governance and religious affairs, who brainstorm ideas for implementation with the promotional motto for morality such as "sufficiency, discipline, honesty,

volunteer spirit".

The philosophy of the sufficiency economy advocates "Self Discipline" as the overriding principle so that even if we have a lot of material wealth or very little of it, still we maintain the right balance (equilibrium) that matches the reality of one's existence and situation.

Everyone should carry out their assigned role and responsibilities, executing their duties at the highest level of honesty. In addition, society needs people with a volunteer spirit, so whoever is in a better position to help others in need, should do it. Do not waste time arguing about it being someone else's job. For example, the combined and joint rescue mission of the "Wild Boar" boy soccer team at the flooded cave of Tham Luang Nang Nuan has shown the world the great Caring Sprit that led to volunteers including officials and citizens both in Thailand and abroad who came with willingness to rescue the boys, even if it meant making the utmost sacrifice. Such volunteerism at all levels from government to farmers who suffered flooding of their own fields, while saying that "There is nothing that can compensate for the lives of children." This is the Big Heart Spirit that we wish to ignite and reinforce in Thai society at large. With such a Caring Spirit, overcoming seemingly impossible circumstances and insurmountable obstacles became possible, and the mission was accomplished in the end. The whole event brought tears, sorrow, faith in humanity and joy to people all over the world. A proof that we can live and share in the same global society with goodness in our hearts.

As a holder of a political position under Prime Minister General Prayut Chan-o-cha, I can firmly say that the government has made dedication to highest level of ethical standards a must-have requirement. According to good governance principles, civil servants must exhibit the highest level of honesty and integrity in carrying out their duties. In my role as Minister to the Prime Minister's Office I serve also as chairman of the Official News Dissemination Committee authorized under the Official Information Act. We adopt a new paradigm that "Public has the right to know as the norm; official secrecy is to be applied only as a rare exception to the rule." We allow and respect people's right to know and receive the most accurate information about the where with all in their nation.

Who decides what should be kept secret from the public due to national security is within the authority of the Information Disclosure Tribunal. At present, there is an agreement for cooperation amongst four public agencies involved in fighting corruption signed by the National Anti-Corruption Commission, Office of the Auditor General Ombudsman and the Office of the Government Information Office, with the shared objective to prevent and suppress misconduct in the public sector. Also in my capacity as the Chairman of the Government Sector Audit and Evaluation Committee I have ensured that criteria on Good Governance are included in any evaluation of political incumbents and government officials.

In the past, the government has continuously tried to implement policies based on good governance principles. For our society to evolve to a high level of morality and ethics we must keep good governance principles close to our hearts. The government is ready to listen to public opinions to ensure that we really practice good governance for the sustainable prosperity, stability and fairness of the nation.

"Integrity is doing the right thing, even when no one is watching"
−C. S. Lewis

From Mr. Suwapan's keynote speech, it is about time for "Good Governance" to go the next level, towards "Great Governance". The key factor is, as in the successful Cave Rescue, that everybody involved in the operation cares about the same mission objective. So they were able to do the impossible, the same "Caring Spirit" can be used to transform from Good to Great with respect to Governance.

This editorial note shines the light on the topic of "Governance" encompassing "Good Corporate Governance" that applies to corporate affairs and "Good Governance" that applies to public affairs in general, and with some audacity expands the scope by bringing governance down to the individual level, myself included. So all of us must watch our own actions, thoughts, character and finally our hearts. Before we can shout that wrong must be right, we have to affirm that we are of the right degree in terms of governance ourselves, otherwise we risk being hypocrites pointing the finger at others who we see as not having good governance, and demanding them to correct their wrong doing(s).

It is posited here that no matter how much money, time and resources have been spent (by government departments, public agencies, companies, charitable organizations, foundations, civil societies etc.) on lecturing about transparency, responsibilities, moralities, rules of law, participation, equity, equality, etc., if the one missing link is not there then no real results will happen. This missing link is the fundamental essence that we must ensure exists in the first place for all those lectures, talks and dialogues to be worthwhile...it is "Caring Heart".

Authorities can give certificates to officials and guests who have attended numerous seminars and workshops who lecture and give long Powerpoint presentations on the many aspects of good governance and best practices that one should know in modern era management and administration, but if the one element is missing (heart that cares deep inside about it) then all those certificates of attendance, titles and positions may serve to no avail.

Thus for any dialogue on "Good Governance" to go to the next level, we must ensure sensitivity and find out if the audience really does "care" about the subject first and foremost. So it is boldly stated here that before we can hurl insults or accusations at a public figure over the topic of governance, we should have the real experience of taking action consistent with governance in our own lives, in our own country, community, school, club, association or any social group we may belong to. Small or big acts do not matter because this is not a competition; it is a contribution to our society and the world we share. From pollution issues (Don't dump rubbish into your canals and rivers or litter your streets) to poaching (Don't kill wildlife and endangered species) to big budget issues (Don't siphon money off public funds destined for public projects). If you want luxuries and enjoy the good life and expensive things, it is okay as long as the money paid for these things was legitimately made and rightfully your own money.

If one really has a "Caring Heart" then the possibility and ability to have self-awareness and self-restraint will come

naturally and everything will balance out. Just knowing that corruption is bad is not enough...time to go to the next level....to feel that corruption is bad in the heart then one would have no excuse but to restrict any urge uncalled for.

With that said, let us really put the Caring Heart into Doing the Right Thing with transparency and open participation to go to the next level, from Good to Great Governance.

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The above Invited Editorial Note was written and translated by Colonel Artcha Boongrapu, B.A. (Essex), M.A. (Kent), Director of Caring Society Network.

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Volume 15, No. 3, May – June 2020

Knowledge and practice on tuberculosis infection control among health care workers in Nay Pyi Taw, Myanmar

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Abstract

Introduction: Poor knowledge and inadequate practice on TB infection control (TBIC) can increase the risk of TB transmission among those directly responsible for TB, TB health care workers (TB HCWs), and general health care workers (General HCWs). The study aimed to compare the knowledge and practice on TBIC between these two groups and determine the predictors for the low level of knowledge and practice.

Methods: A cross-sectional study was conducted in Nay Pyi Taw, Myanmar, from September 2019 to January 2020. HCWs assigned for TB, multi-drug resistant TB (MDR-TB) care, diagnostic and prevention activities were included as TB HCWs, and those working at the general hospitals not directly responsible for TB patients were recruited as general HCWs. A total of 260 TB HCWs and 500 general HCWs were invited. Knowledge and practice on TB infection control among health care workers were assessed using the structured questionnaire. Participants were categorized as having low knowledge if their knowledge scores were below the mean score and likewise for practice.

Results: Knowledge and practice scores were significantly higher among TB HCWs. With a maximum possible score of 10 for knowledge questions, the mean (SD) score of TB HCWs and general HCWs were 9.31 (0.987) and 7.35 (2.40), respectively, the p value of t-test 0.0095. With a maximum possible score of 7 for practice items, the mean (SD) score of TB HCWs and general HCWs were 4.718 (1.17) and 3.136 (1.441), respectively, the p value of t-test 0.036. Being ward staff and over 30 years old TB HCWs were the predictors of low knowledge. The predictors of poor practice were doctor, nurse, receptionist, ward staff, and those who had not been trained in TBIC.

Conclusion: More TBIC programme should be enhanced among health care workers, especially in risk groups, whose knowledge and practice were poor.

Keywords: Infection control, health care worker, tuberculosis

1. Introduction

Tuberculosis (TB), an infectious disease caused by *Mycobacterium tuberculosis*, can transmit from one person to another via the air [1]. In 2017, sixty-five countries reported that a total of 9,299 health care workers were with TB. Myanmar is one of high TB burden countries, and nearly 90% of TB cases are pulmonary TB, and 41% of them are bacteriologically confirmed cases [2].

The risk of coming into contact with infectious diseases, including TB is higher among people who work or dwell in hospitals, shelters, and correctional facilities [3]. Being health care workers (HCWs) increase the risk for active TB regardless of whether he or she directly contact with TB patients [4]. In diminishing the risk of occupationally acquired TB, it is vital to reduce the concentration of infectious droplet nuclei in the environment and the exposure of susceptible individuals to that aerosol [3, 5 – 7].

TB infection control (TBIC) composes of three portions: administrative control, environmental control, and personal protective measure. The first prioritized administrative control contains triage of people with TB signs and symptoms, manage the patients to flow rapidly, and initiation of effective treatment punctually. Environmental control is attained by natural ventilation or using a special ventilation system to maximize airflow rate, or by using germicidal ultraviolet (GUV) to disinfect the air. Poor knowledge and inadequate practice on TBIC [8] can increase the risk of TB transmission among those directly responsible for TB, TB health care workers (TB HCW), and general health care workers (general HCW).

TB services in Myanmar are delivered at the TB clinics under the department of public health. TB Program staff such as team leader, TB coordinator, and basic health staff are assigned at the clinics for the diagnosis, patients' enrollment, follow up care, directly observed treatment (DOT), contact tracing, and TB drug injection. However, some proportion of presumptive TB patients visit the outpatient department at the general hospitals. As a limited resource country like Myanmar, it has the challenge of utilizing the expensive TB infection control commodities at all health care facilities. However, simple measures, which are parts of the standard TBIC, are recommended to apply at all the general hospitals and TB health care facilities. TBIC materials such as GUV, fan, and N95 mask are specially supplied to the multi-drug resistant TB treatment initiation centers.

Myanmar National TB Programme (NTP) has rolled out the TB infection prevention and control guidelines in line with WHO recommendation since 2015 [9, 10]. Assessment of knowledge and practice among HCWs can provide useful information about the gaps in implementing TB infection control measures in the real situation. The studies in high TB prevalence countries have reported that age, length of service, and the training [11] were associated with the level of knowledge and practice of TBIC [12, 13]. However, little is known about the HCWs' knowledge and practice on TBIC and how it is different between TB HCW and general HCW. It is also not known HCWs with what specific background should be targeted. Therefore, this study aimed to compare the knowledge and practice on TBIC between general HCWs and TB HCWs and determine the predictors for the low level of knowledge and practice.

2. Methods

2.1 Ethics approval

The study protocol was approved by the Institutional Ethics Committee of Faculty of Medicine, Prince of Songkla University, Hat Yai, Thailand (62-263-18-1) and Institutional Review Board (1), Ministry of Health and Sports, Myanmar (2019-010). All participating health care workers provided informed written consent.

2.2 Study design and setting

A cross-sectional study was conducted in Nay Pyi Taw, Myanmar, from September 2019 to January 2020. This is also a part of the study that measured the prevalence of latent TB infection among general and TB HCWs. As of January 2019, there were 23 hospitals in Nay Pyi Taw, and only two hospitals have TB services. Depending on the presence of TB service, we selected two hospitals, and all of the HCWs who work at the TB facilities and the general hospitals were invited to join the study. However, HCWs who took leave or absent during the study period and not willing to participate in the study were excluded.

2.3 Study participants

HCWs assigned for TB/MDR-TB care, diagnostic, and prevention activities were defined as TB HCWs, and those working at the general hospitals not directly responsible for TB patients were termed as general HCWs. There were 260 eligible TB HCWs, which included team leader, nurses, TB coordinators, TB clinic staff, and basic health staff. General HCWs included doctors, nurses, pharmacists, technicians, administrative staff, and ward staff at the general hospitals, and the total eligible numbers were 500 in this group.

2.4 Questionnaire preparation

The questionnaire was adapted from WHO's TB infection control and practice and related literature [9, 14, 15]. It was modified into local context under the consensus of TB technical experts. The questionnaire was prepared in English and then translated to the local language (Myanmar) and finally reverse translated to English by an independent translator to make sure that the contents were not distorted. A pre-test was done in 5% of HCWs in the study area, which was not included in the actual study. Analysis of internal consistency revealed Kuder Richardson's value of 0.72. There were three domains in knowledge and practice assessment: administrative, environmental, and personal protective domain. Knowledge questions consisted of 6 items from the administrative domain, two items each from the environmental and personal protective domain. Practice questions composed of 3 administrative items, 2 environmental items, and 2 personal protective items. Knowledge about TBIC was measured using 10 questions, each with two possible answers. The score "1" was given to the corrected response and "0" for the wrong one, and the range of total score was 0 to 10. Similarly, for the practice and so the range of overall score was 0 to 7.

2.5 Data collection

Three interviewers were trained and supervised by the principal investigator on how to conduct face to face interviews using a structured questionnaire and how to check the information completeness. The potential study subjects were informed about the study and asked to give informed consent. The consent subjects were then interviewed. Each interview session took around 15 minutes.

2.6 Variables and measurement

The dependent variables were knowledge and practice on TB infection control. The main independent variable was general versus TB HCW, and others included background characteristics (age, gender, level
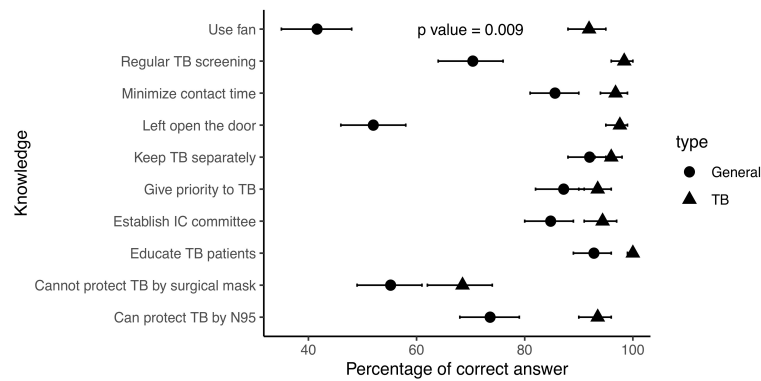
Figure 1: Knowledge on TBIC among general HCWs and TB HCWs.
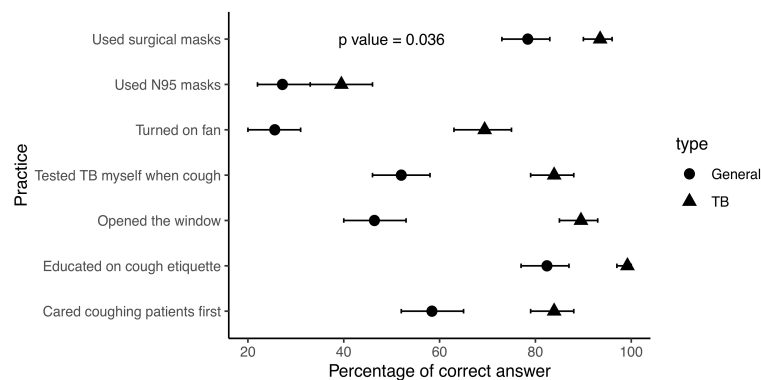
Figure 2: Practice on TBIC among general HCWs and TB HCWs.

of education, had taken IC training) as potential confounders. The mean scores of knowledge and practice questions were equivalent to 83% and 60% of the full score. Participants were categorized as having low knowledge if their knowledge scores were below the mean score and likewise for practice.

2.7 Statistical analysis

All the data were entered twice using EpiData and analyzed using R software (version 3.6.2). The characteristics of health care workers were presented with frequencies and percentages. Statistical significance of the difference in knowledge and practice of TBIC between two groups of HCWs was assessed by the p-value of the two-sample t-test. Validation on combining odds ratios of each independent variable among general and TB HCWs strata was performed by using the Mantel-Haenszel method. If the homogeneity test was significant, strata specific measures of the association were implied. Predictors for low knowledge and poor practice on TBIC were analysed using multivariable logistic regression with variables showing P < 0.20 in the univariate analysis included as potential confounders. The model with the lowest AIC value was chosen, and the main independent variable was also imported into the model if it was not included in the selected one.

3. Results

3.1 Background characteristics of health care workers

Of 500 eligible general HCWs and 260 TB HCWs, 250 and 248 joined the study, response rates of 50%, and 95%, respectively. Table 1 compares the background characteristics of both groups. TB HCWs were younger, more educated, and had shorter service experience, a narrower spectrum of the profession, and higher exposure to TB.

3.2 Knowledge of TB infection control measures and predictors of low knowledge

With a maximum possible score of 10 for knowledge questions, the mean (SD) score of TB HCWs and general HCWs were 9.31 (0.987) and 7.35 (2.40), respectively, the p-value of t-test 0.0095.

Fig. 1 presents the percentages of HCWs who provided correct answers to each knowledge question. TB HCWs got a consistently higher score for all items. Moreover, in all aspects of knowledge questions, the proportion of TB HCWs who gave correct answers was over 80% except for the protection of TB infection by using the surgical mask. For general HCWs, only 5 items in knowledge questions were above 80%. There is a huge score gap in 4 items of knowledge

Table 1. Background characteristics of health care workers.

Variable	General HCW n (%)	TB HCW n (%)	P value
Total	250	248	
Age			< 0.001
20–29	124 (49.6)	203 (81.9)	
30+	126 (50.4)	45 (18.1)	
Gender			0.617
Female	194 (77.6)	198 (79.8)	
Male	56 (22.4)	50 (20.2)	
Education level			< 0.001
Graduated	154 (61.6)	236 (95.2)	
Not graduated	96 (38.4)	12 (4.8)	
Profession			< 0.001
Admin staff	38 (15.2)	0 (0)	
Basic Health staff	0 (0)	226 (91.1)	
Doctor	10 (4)	2 (0.8)	
Nurse	130 (52)	20 (8.1)	
Receptionist	8 (3.2)	0 (0)	
Ward staff	64 (25.6)	0 (0)	
Total service years			< 0.001
< 10	166 (66.4)	224 (90.3)	
10+	84 (33.6)	24 (9.7)	
Exposure to TB suspects			< 0.001
No	180 (72)	36 (14.5)	
Yes	70 (28)	212 (85.5)	
Exposure to TB patients			< 0.001
No	178 (71.2)	56 (22.6)	
Yes	72 (28.8)	192 (77.4)	
Exposure to MDR TB patients			0.876
No	198 (79.2)	194 (78.2)	
Yes	52 (20.8)	54 (21.8)	
Had taken IC training			< 0.001
No	244 (97.6)	138 (55.6)	
Yes	6 (2.4)	110 (44.4)	

questions: (1) Use fan to reduce TB transmission (2) Regular TB screening by HCW is one of TB control (3) Left open the door when TB suspects or confirmed is in the room and (4) Can protect HCW from TB by N95 mask. Nevertheless, both groups got a low score on the fact "Cannot protect HCW from TB by using the surgical mask."

Considering that having low knowledge is a risk for TB infection, logistic regression results in Table 2 reveal that the risk groups were general HCWs and older age group of TB HCWs. Regarding the professions, the risk of low knowledge was higher among the ward staff compared with admin staff. It should be noted that those directly exposed to TB patients got a low risk of having poor knowledge.

3.3 Practice on TB infection control measures and predictors of poor practice

With a maximum possible score of 7 for practice items, the mean (SD) score of TB HCWs and general HCWs were 4.718 (1.17) and 3.136 (1.441), respectively, the p-value of t-test, 0.036.

Fig. 2 provides a comparison of practice on TB infection control between two groups. Generally, the practice score of TB HCWs was higher than that of general HCWs. The proportion of HCWs who practiced TBIC was more than 80%, excluding usage of fan and N95 mask whenever treating TB patients. The proportion of general HCWs who educated TB patients on cough etiquette was 80%, which was the highest one among 7 practice questions. The practice with the lowest score in both groups was "Used N95 mask whenever contacted with TB patients or specimens."

Considering that having poor practice is also a risk for TB infection, logistic regression results in Table 3 show that the risk groups were doctor, nurse, receptionist, ward staff, and HCWs who had not been trained for TBIC. However, the likelihood of having poor practice was not significantly different between general HCWs and TB HCWs.

4. Discussion

This study reveals that general HCWs had poorer knowledge of TBIC than TB HCWs, but their practices were not statistically significantly different. In addition, predictors for poor knowledge included ward staff and the older age group of TB HCWs. On the other hand, predictors for poor practice were doctors,

Table 2. Predictors of low knowledge (below mean score) on TB infection control using logistic regression.

Variable	crude OR (95%CI)	adj. OR (95%CI)	P value
Type: TB HCW vs General HCW	0.12 (0.07,0.2)	0.1 (0.02,0.6)	0.012*
Profession: ref.=Admin staff			
Basic Health staff	0.21 (0.09,0.48)	3.14 (0.53,18.7)	0.21
Doctor	2.17 (0.58,8.13)	2.63 (0.66,10.43)	0.169
Nurse	0.96 (0.45,2.06)	1.43 (0.63,3.24)	0.386
Receptionist	2.17 (0.46,10.16)	2.04 (0.43,9.65)	0.37
Ward staff	5.54 (2.31,13.28)	7.29 (2.93,18.16)	< 0.001*
Exposure to TB patients: Yes vs No	0.24 (0.16,0.37)	0.39 (0.22,0.67)	0.001*
Age 30+: type TB HCW	4.55 (1.82, 11.34)	6.32 (2.06,19.35)	0.001*
Had taken IC training: Yes vs No	0.2 (0.1,0.39)	0.59 (0.25,1.38)	0.224

*P value < 0.05

Table 3. Predictors of poor practice (below mean score) on TB infection control using logistic regression.

Variable	crude OR (95%CI)	adj. OR (95%CI)	P value
Type: TB HCW vs General HCW	0.12 (0.08,0.19)	0.63 (0.16,2.54)	0.519
Education level: Not graduated vs Graduated	2.89 (1.87,4.48)	0.38 (0.14,1.04)	0.061
Profession: ref.=Admin staff			
Basic Health staff	0.5 (0.22,1.11)	2.53 (0.48,13.33)	0.273
Doctor	14 (2.61,75.2)	30.33 (3.39,271.65)	0.002*
Nurse	2.88 (1.31,6.34)	5.3 (1.94,14.54)	0.001*
Receptionist	8.4 (1.45,48.61)	17.47 (2.12,143.95)	0.008*
Ward staff	10 (3.93,25.45)	16.89 (4.57,62.43)	<0.001*
Exposure to TB suspects: Yes vs No	0.23 (0.15,0.33)	0.37 (0.13,1.06)	0.064
Exposure to TB patients: Yes vs No	0.32 (0.22,0.46)	2.14 (0.73,6.27)	0.166
Exposure to MDR TB: Yes vs No	0.67 (0.42,1.06)	0.54 (0.26,1.12)	0.098
Had taken IC training: Yes vs No	0.14 (0.07,0.26)	0.38 (0.18,0.8)	0.011*

*P value < 0.05

nurses, receptionists, and ward staff. IC training has no impact on TBIC knowledge but positive effect on practice.

This study highlights the level of knowledge and practice on TBIC among health care workers in Myanmar. A comparison between two groups shows that general HCWs got lower scores in each knowledge and practice question. This may have some more explanation. As Myanmar National TB Program is a vertical program, TB-related training and supplies were mostly offered to TB staff. Therefore, TB HCWs had more chance of getting TB-related new knowledge. Accordingly, TBIC knowledge and practice should be enhanced among health care workers at the hospitals.

It was found that older age was significantly associated with low knowledge among the TB HCWs group. It is consistent with the finding from the previous study in Vietnam [12]. In addition, being ward staff was also associated with poor knowledge. However, the study did not find the association between background education level and poor knowledge after adjustment for other potential confounders. Another finding was that HCWs who exposed to TB patients were less likely to have low knowledge. It means a person who worked on TB had more knowledge of TB infection control measures. Another study also found that attending the training or workshop was associated with a high score of knowledge [12, 13], but the find-

ing in our study did not support this association.

According to this study, the targeted groups to improve TBIC practice were doctors, nurses, receptionists, and ward staff. Moreover, health care workers who got training on TBIC practiced more on infection prevention measures than the untrained. This finding was consistent with the study conducted in Nigeria [13]. The practice of using N95 in both groups was not satisfactory. NTP expects the HCW to use against MDRTB only, but this kind of expensive mask was overused for any TB symptoms. According to standard IC guidelines, however, it could be said that there were limited N95 masks among health care workers.

This study has some limitations. It might have a respondent bias because of the high percentage (>50%) of non-responders among general health care workers. Measuring the practice with a structured questionnaire may yield answers biased toward expectation.

5. Conclusion

This study highlights that general health care workers get a lower score in each of the knowledge and practice items than the TB HCWs. More TBIC programme should be enhanced among health care workers, especially in the risk groups, whose knowledge and practice were poor.

Acknowledgment

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A model of work-integrated learning to prepare educational administrators for Thailand

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Abstract

This research aimed to 1) synthesize components of work-integrated learning, 2) investigate current conditions, problems, and factors supporting to success, and 3) develop and verify a model of work-integrated learning to prepare educational administrators for Thailand. Instruments used in this research were a component synthesis, an open-ended question, and a 5 rating-scale questionnaire. Data were analyzed by mean and standard deviation. Results of the research were found that the work-integrated learning consisted of 5 components. The current conditions were overall at a high level, problems were overall at a moderate level, and all factors supporting to success were overall at a high level, especially factors concerning curriculum and learners. The developed model of work-integrated learning was named "POSO (ria) CDEM" model, consisting of 8 components. The model used for the development had the processes of developing knowledge and experiences to prepare educational administrators for Thailand consisted of 5 steps as follows: 1) creating basic knowledge, 2) practicing how to teach thinking, 3) bringing thinking skills to the classroom, 4) exchanging work reflections, and 5) organizing the sustainable work system. As regards the model verification, it was found all experts had verified the accuracy and suitability. Therefore, the developed model could be used as a master model to publish all over Thailand.

Keywords: Model, work-integrated learning, educational administrators

1. Introduction

As we knew that, quality education is an indicator of social-well-being to support the goals of Thailand 4.0 and enhance human values with educational opportunities thoroughly across a global network. Likewise, Thai higher education institution has played an important role in Thailand's development, politics, and society, Thai Qualifications Framework for Higher Education, TQF: HEd, Royal Thai Government Gazette [13] determined students' qualifications covering the domains of learning at least 5 aspects as follows: 1) morality and ethics, 2) body of knowledge, 3) cognitive skills, 4) interpersonal relationship and responsibility, and 5) numerical analysis skill, communicative and informative technology skills.

Regarding the term of work-integration education in accordance with 20-Year Long Range Plan on Higher Education of Thailand, B.E. 2561 – 2580 (2018 – 2037) Bureau of Policy and Planning, Office of the Higher Education Commission (OHEC) [3] was reported the impact of dimension analysis on higher education quality if it was compared to trends of demand

in the future development of the country. It was found that the quality of Thai education was the most important factor to define a new concept of educational quality as well as the concept of educational standards should be considered the importance of the determination of new higher education standards by focusing on the learners' potential which consisted of knowledge, skills, and desirable characteristics of graduates that met the needs of national development in various dimensions. An important issue, therefore, involved with the determination of new higher education standards, learning outcomes, curriculum standards, including educational measurement and evaluation. Moreover, the reform of teaching and learning, creating a new standard for Thai higher education quality depending on ability to reform teaching and learning with new learning concepts or theories in the 21st century and the influence of digital technology with the systemic building to support professional development in terms of teaching and new student development, it would make the faculty lecturers had to learn and develop themselves in accordance with international standards in higher education, including work-integration education management or providing students with the opportunity to work with the private

sector, and do the research to find the manufacturing sector (Talent Mobility), it would make graduated production did not aim for degrees but focusing on working and job creation leading to sustainable development for Thailand.

Likewise, M. Andy and H. Helen [7] stated concerning work-integrated learning experiences was to supply a bridge for the students between the scholarly show, and their proficient future - an opportunity to apply and combine theoretical knowledge gained in scholar studies to world of practical experiences, and to plan the students for a career by giving an opportunity to create significant proficient skills. Therefore, work-integrated learning (WIL) referred to university initiatives in fieldwork.

Concerning the announcement of Teachers' Council of Thailand, Royal Thai Government Gazette [11] defined the curriculum standards in section 2.2 stipulated the following criteria: 1) course description compulsory consisted of standards of knowledge and competencies in each standard, not less than that specified by Teachers Council of Thailand, 2) there was a plan of activities for work-integrated learning to promote educational administrative leadership of educational administrators periodically throughout the curriculum, and 3) the practicum management of school administration and educational administration was not less than 3 credits.

Additionally, the desirable characteristics of students studying major in Educational Administration should follow the Regulation of the Teachers Council of Thailand on Professional Ethics B.E. 2562 (2018), Royal Thai Government Gazette [12] announced in article 3 concerning standards of working, referred to the requirements of characteristics or performance behavior, and job development which educational professions including those who wanted to work in the educational profession must follow to achieve the objectives and learning goals or educational management including the need to self-practice and self-development to have skills or increased expertise continually.

From the study of concepts related to work-integrated learning (WIL) model, it could be concluded that the integrated education and work-integrated learning (WIL) for learners by linking learning in the classroom or educational institutions with work experiences in learning resources in the real situation which was designed in the course systemically for learners to achieve the determined learning outcomes. It is believed that the model of work-integrated learning to prepare educational administrators for Thailand will be very useful for the education industry, especially the educational administration program including building a network management in order for the collaboration in school administration to be the modern progressive institutions.

2. Research Questions

2.1 What are the components of work-integrated learning to prepare educational administrators for Thailand?

2.2 What are current conditions, problems, and factors supporting to success of work-integrated learning to prepare educational administrators for Thailand?

2.3 What are the results of developing and verifying a model of work-integrated learning to prepare educational administrators for Thailand?

3. Research Objectives

3.1 To synthesize the components of work-integrated learning to prepare educational administrators for Thailand.

3.2 To investigate current conditions, problems, and factors supporting to success of work-integrated learning to prepare educational administrators for Thailand.

3.3 To develop and verify a model of work-integrated learning to prepare educational administrators for Thailand.

4. Materials and Methods

The research process was divided into three phases as follows:

Phase 1: Synthesize the components of work-integrated learning to prepare educational administrators for Thailand was divided into 2 steps:

Step 1.1: The researchers synthesized the theoretical components concerning work-integrated learning from 14 educators. Nine key components were determined the criteria by selecting to be the components of work-integrated learning and were consensus by at least 7 theoretical educators concerning work-integrated learning, so it was considered to be components for work-integrated learning.

Step 1.2: Synthesis results were verified and confirmed the components with the Delphi technique for 2 rounds by 21 experts as key informants, consisting of educational administrators and school administrators selected by purposive sampling. Instruments used were divided as follows: the first round: an open-ended question was used to ask for opinions, to verify the suitability or unsuitability, and to give reasons, the second round: a 5 rating-scale questionnaire was used to ask for opinions based on the importance of the questions with IOC = 1.00. Median and Interquartile Range were used to synthesize data.

Phase 2: Investigate the current conditions, problems, and factors supporting to success of work-integrated learning to prepare educational administrators for Thailand, the sample group was derived by multi-stage sampling from former students/current students, and lecturers of educational administration

major. There were 13 key informants from each university consisting of 10 former students/current students and 3 lecturers of educational administration major. Instrument used was a questionnaire with reliability at 0.93, dividing into 3 parts:

Part 1: The investigation of current conditions were analyzed by using mean and standard deviation.

Part 2: The investigation of problems were analyzed by using mean and standard deviation.

Part 3: The investigation of factors supporting to success were analyzed by mean and standard deviation.

Phase 3: Develop and verify of a model of work-integrated learning to prepare educational administrators for Thailand were as follows:

Step 3.1: As regards the development of a model of work-integrated learning to prepare educational administrators for Thailand, the researcher used the results from phase 1 and phase 2 to draft or develop the model by applying the concepts of R. Teera [10], and A. Saman [1] to be 8 model components as follows: 1) principles, 2) objectives, 3) system and mechanism, 4) procedures, 5) guidelines for operational methods, 6) definitions, 7) successful conditions of model implementation, and 8) manual of model implementation.

Step 3.2: As regards the verification of a model of work-integrated learning to prepare educational administrators for Thailand, the model draft was verified by specialists and improved according to the specialists who were selected by purposive sampling consisted of director or deputy director of educational area, regional education, personnel from Teachers Council of Thailand, and school directors who were concerning the practicum of educational administration.

The research framework was as shown in Fig. 1.

5. Results and Discussion

The results of this research were as follows:

Phase 1: The components of work-integrated learning to prepare educational administrators for Thailand were divided into 2 steps:

Step 1: Nine key components were synthesized from the theoretical concepts concerning work-integrated learning by 14 educators, it was found that 1) policy, 2) the preparation of agencies or establishment, 3) instruction, 4) the acquired knowledge, 5) career skills, 6) curriculum, 7) organizations/educational institutions, 8) learners, and 9) lecturers.

Step 2: The results of verification and confirmation of components were divided into 2 parts:

Part 1: Synthesis results were verified and confirmed the components with the Delphi technique for 2 rounds by 21 experts as key informants, consisting of educational stakeholders selected by purposive sampling. The first round was used to ask the experts' opinions, it was found that the experts' con-

sensus to collapse the key components from 9 components to 5 components and renamed as follows: 1) educational policy, 2) the preparation of production agencies/practicum agencies/educational agencies, 3) curriculum/knowledge/career skills/instructional management, 4) the learners' competencies, and 5) lecturers' competencies.

Part 2: The analysis results of the second round from asking for opinions from the 5 rating-scale questionnaire analyzed by Median and Interquartile Range in order to verify and confirm 5 components of work-integrated learning to prepare educational administrators for Thailand, the suitability was from a high to the highest level and the consistency was overall lower than 1.50 (Mdn. $= 4.00 - 5.00$, IQR $= 0.00 - 1.00$) according to the criteria as shown in Table 1:

From Table 2, the 21 experts verified and confirmed 5 components of work-integrated learning to prepare educational administrators for Thailand, the suitability was from a high to the highest level and the consistency was overall lower than 1.50 (Mdn. $= 4.00 - 5.00$, IQR $= 0.00 - 1.00$) according to the criteria.

Regarding the finding components of work-integrated learning, it was also similar to J. Sarah and M. Margaret [5] studied 'Work Integrated Learning (WIL): Integrating Frameworks for Education and Practice', it was found that appraisal of their curriculum model which focused on transformative learning, demonstrated that it was characterized by elements consistent with problem or practice-based curricula and WIL: 1) the use of stimulus material that reflects the dilemmas that represent nursing issues and contexts for learning, 2) a focus on higher order thinking skills, 3) aspirations for integration of knowledge, skills and behaviors, 4) learning in groups and working as a team member, and 5) self-directed learning, particularly through a range of media including online.

There was different from Miller's (1990 as cited in Higher Education Quality Council of Ontario) [4], this was a conceptual model that that's particularly well known within the learning evaluation of students in the well-being sciences, but could be connected to any organized work involvement. Miller's Triangle distinguished the components of clinical competence as: Information (i.e., knows), Competence (i.e., knows how), Performance (i.e., appears how), and Activity (i.e., does)

Phase 2: The investigation of current conditions, problems, and factors supporting to success of work-integrated learning to prepare educational administrators for Thailand, the sample group was derived by multi-stage sampling from former students/current students, and lecturers of educational administration major all over Thailand. There were 13 key informants from each university consisting of 10 former students/current students and 3 lecturers of educational administration major, for a total of 390 key in-
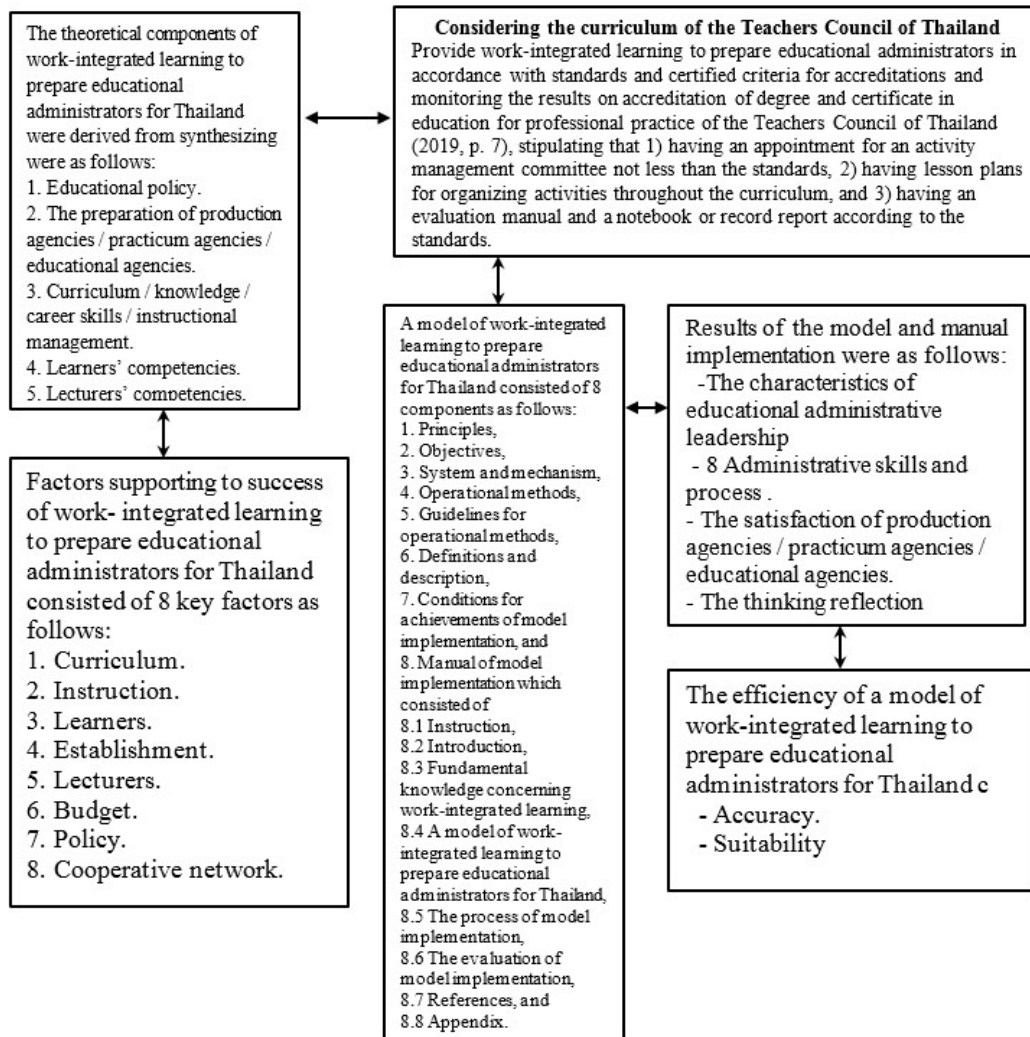
The theoretical components of work-integrated learning to prepare educational administrators for Thailand were derived from synthesizing were as follows:
1. Educational policy.
2. The preparation of production agencies / practicum agencies / educational agencies.
3. Curriculum / knowledge / career skills / instructional management.
4. Learners' competencies.
5. Lecturers' competencies.

Considering the curriculum of the Teachers Council of Thailand
Provide work-integrated learning to prepare educational administrators in accordance with standards and certified criteria for accreditations and monitoring the results on accreditation of degree and certificate in education for professional practice of the Teachers Council of Thailand (2019, p. 7), stipulating that 1) having an appointment for an activity management committee not less than the standards, 2) having lesson plans for organizing activities throughout the curriculum, and 3) having an evaluation manual and a notebook or record report according to the standards.

Factors supporting to success of work- integrated learning to prepare educational administrators for Thailand consisted of 8 key factors as follows:
1. Curriculum.
2. Instruction.
3. Learners.
4. Establishment.
5. Lecturers.
6. Budget.
7. Policy.
8. Cooperative network.

A model of work-integrated learning to prepare educational administrators for Thailand consisted of 8 components as follows:
1. Principles,
2. Objectives,
3. System and mechanism,
4. Operational methods,
5. Guidelines for operational methods,
6. Definitions and description,
7. Conditions for achievements of model implementation, and
8. Manual of model implementation which consisted of
8.1 Instruction,
8.2 Introduction,
8.3 Fundamental knowledge concerning work-integrated learning,
8.4 A model of work-integrated learning to prepare educational administrators for Thailand,
8.5 The process of model implementation,
8.6 The evaluation of model implementation,
8.7 References, and
8.8 Appendix.

Results of the model and manual implementation were as follows:
 -The characteristics of educational administrative leadership
 - 8 Administrative skills and process .
- The satisfaction of production agencies / practicum agencies / educational agencies.
- The thinking reflection

The efficiency of a model of work-integrated learning to prepare educational administrators for Thailand c
 - Accuracy.
 - Suitability

Figure 1

formants. Instrument used was a questionnaire dividing into 3 parts:

Part 1: The current conditions of work-integrated learning to prepare educational administrators for Thailand were indicated as shown in Table 2:

From Table 2, the findings of the level of current conditions of work-integrated learning to prepare educational administrators for Thailand: five aspects were overall at a high level, the first current conditions was learners' competencies, followed by lecturers' competencies, and educational policy was at the last, respectively.

Part 2: The problem conditions of work-integrated learning to prepare educational administrators for Thailand were indicated as shown in Table 3:

From Table 3, the findings of the level of problem conditions of work-integrated learning to prepare educational administrators for Thailand: five aspects were overall at a moderate level, the preparation of production agencies / practicum agencies / educational agen-

cies was the first problem condition, followed by curriculum / knowledge / career skills / instructional management, and learners' competencies was at the last, respectively.

Part 3: The factors supporting to success of work-integrated learning to prepare educational administrators for Thailand were indicated as shown in Table 4:

From Table 4, the findings of the level of factors supporting to success of work-integrated learning to prepare educational administrators for Thailand: eight aspects were overall at a high level learners had factors supporting to success at the first, followed by curriculum had factors supporting to success, and financial had factors supporting to success at the last, respectively.

Concerning the investigation results of current conditions, problems, and factors supporting to success of work-integrated learning to prepare educational administrators for Thailand, Higher Education Quality Council of Ontario [4] recommended for enhanced

Table 1. Median and interquartile range and meaning by 21 experts.

No.	Experts' opinions	Mdn.	Meaning	IQR	Meaning
1	Educational policy	4.00 – 5.00	The most suitability.	0.00 – 1.00	Consensus
2	The preparation of production agencies/practicum agencies/educational agencies	5.00	The most suitability.	0.00 – 1.00	Consensus
3	Curriculum/knowledge/career skills/instructional management	5.00	The most suitability.	0.00 – 1.00	Consensus
4	Learners' competencies	5.00	The most suitability.	0.00 – 1.00	Consensus
5	Lecturers' competencies	5.00	The most suitability.	0.00 – 1.00	Consensus

Table 2. Mean, standard deviation, and level of current conditions by 390 key informants.

No.	Current conditions	Mean	S.D.	Meaning	Level
1.	Educational policy	3.64	0.83	High	5
2.	The preparation of production agencies/practicum agencies/educational agencies	3.78	0.85	High	4
3.	Curriculum/knowledge/career skills/instructional management	3.82	0.82	High	3
4.	Learners' competencies	4.00	0.82	High	1
5.	Lecturers' competencies	3.91	0.82	High	2
	Total Average	**3.83**	**0.82**	**High**	

integration included: integrated learning as a shared obligation between all relevant partners; faculty lecturers built integration into organized work-integrated learning through learning results and evaluation; graduate students might create an action plan that reintroduced theoretical or practical factors to solidify learning from the field.

Phase 3: Results of the development and verification of a model of work-integrated learning to prepare educational administrators for Thailand were as follows:

Step 3.1: Results of developing the model of work-integrated learning to prepare educational administrators, the development model was named "POSO (ria) CDEM" model, consisting of 8 components.

1. P = Principles: Model principles were activities management on work-integrated learning.

2. O = Objectives: Model objectives were to development activities of work-integrated learning to prepare educational administrators.

3. S = System: Model system and mechanism concerning committee was appointed to manage activities according to standards.

4. O = Operational methods were as follows:

4.1 r = requirement analysis: Analyze the development requirement of educational administrative leadership was for planning analysis for development of educational administrative leadership and operational guidelines for integrating with work.

4.2 i = integration: Knowledge combination of educational administrative leadership and activities of work-integrated learning in terms of knowledge management / practicum/ activities of work-integrated learning in schools and knowledge conclusion of educational administrative leadership.

4.3 a = assessment: Results assessment was to improve and development.

5. C = Conditions: Conditions for achievements of model implementation was concerning the students passed the criteria of educational administrative leadership.

6. D = Definitions: Model definitions and description.

7. E = Evaluation: Model evaluation and measurement were to develop of educational administrative leadership and activities of work-integrated learning to prepare educational administrators for Thailand.

8. M = Manual: Manual of model implementation

The findings of these steps were similar to the concepts of R. Teera [10], and A. Saman [1] to be 8 model components as follows: 1) principles, 2) objectives, 3) system and mechanism, 4) operational methods, 5) guidelines for operational methods, 6) definitions and description, 7) conditions for achievements of model implementation, and 8) manual of model implementation. It was similar to N. L. Chawinnawat [6] found that the integrated administration model for enhancing quality of world class standard schools was composed of principle, objectives, system, mechanism and operational methods. It was different from M. Clayton [8] had received 5 key components of model development, implementation, and use as follows:1) model definition and requirements, 2) model design, 3) data management, 4) analysis of results, 5) continuous feedback and improvement.

Additionally, there were 21 activities of work-integrated learning throughout the course. The model used for the development had the processes of developing knowledge and experiences for educational administrators consisted of 5 steps as follows: 1) creat-

Table 3. Mean, standard deviation, and level of problem conditions by 390 key informants.

No.	Problem conditions	Mean	S.D.	Meaning	Level
1.	Educational policy	2.91	0.97	Moderate	3
2.	The preparation of production agencies/practicum agencies/educational agencies	2.94	0.94	Moderate	1
3.	Curriculum/knowledge/career skills/instructional management	2.92	0.92	Moderate	2
4.	Learners' competencies	2.78	0.88	Moderate	5
5.	Lecturers' competencies	2.79	0.86	Moderate	4
	Total Average	**3.83**	**2.86**	**Moderate**	

Table 4. Mean, standard deviation, and level of problem conditions by 390 key informants.

No.	Factors supporting to success	$\bar{x}$	S.D.	Meaning	Level
1.	Curriculum	4.24	0.66	High	2
2.	Instruction	4.12	0.69	High	7
3.	Learners	4.29	0.61	High	1
4.	Establishment	4.22	0.64	High	4
5.	Lecturers	4.21	0.66	High	5
6.	Financial	4.04	0.68	High	8
7.	Policy	4.15	0.68	High	6
8.	Cooperative network	4.23	0.64	High	3
	Total Average	**4.18**	**0.65**	**Moderate**	

ing basic knowledge, 2) practicing how to teach thinking, 3) bringing thinking skills to the classroom, 4) exchanging work reflections, and 5) organizing the sustainable work system.

It was similar to M. Windschitl (2002 as cited in P. Elize) [9] suggested administrator teachers/mentors utilized an assortment of evaluation techniques to get it how students' thoughts were advancing and to provide input on the forms and the items of their considering.

Regarding this, Upper Southern Cooperative Education Network, Office of the Higher Education Commission (OHEC), Thailand [14] concluded that the integrated education and work-integrated learning (WIL) for learners by linking learning in the classroom or educational institutions with work experiences in learning resources in the real situation which was designed in the course systemically for learners to achieve the determined learning outcomes. Similarly, B. Nicolene, and S. Nico [2], the finding of the study resulted in the development of the following integrated model in terms of higher education institutions and centres for cooperative education to attempt to move forward a student's self-confidence and self-concept, create student's social aptitudes, develop world information, and steps to work openings to be an vital perspective within the nation. Step 3.2: As regards the model verification, it was found all experts had verified the accuracy and suitability. Therefore, the developed model could be used as a master model to public.

It might be because of the developed model had the process of building with the research procedures in the right methods systematically, all experts strongly agreed and guarantee to use for educational manage-

ment in a variety of Thai universities.

6. Conclusion

It is therefore obvious that another important role of universities is to provide opportunities for students to practicum in their educational institutions so they can use their learning experiences into the future career. Work integrated learning isn't new to university education, but it accesses in Thai universities because students have to adapt themselves to keep on the future era, so practicum should be the compulsory as one course of their studies in Thailand.

7. Recommendations

From this research, the recommendations are made as follows:

7.1 This developed model is used for work-integrated learning to prepare educational administrators for Thailand, the author has suggested that the faculty lecturers/staff who are responsible with the curriculum of educational administration major should study concerning this model in order to understand roles and duties of stakeholders in each part, desirable characteristics, and competency including how to evaluation educational administrative leadership in preparation for Thailand in the further operations.

7.2 The responsible committee for the practicum project and/or activities for the preparation of work-integrated learning should analyze and plan for development of educational administrative leadership, guidelines for work-integrated learning, preparing learning processes/practicing experiences/organizing

integrated activities with school work and summarizing the knowledge of being an educational administrative leadership in order to organize development activities in various parts to cover all aspects, all issues both the integration with the learning process and practicum with normal work and develop students' self-diversity to be complete and arrange for periodic assessments and after the end of development, And meetings and seminars should be provide to relevant stakeholders.

7.3 All faculty lecturers/staff Instructors in each course should analyze the course descriptions, objectives, knowledge, skills, competencies and desirable characteristics of educational administrators to emphasize on the preparation the work-integrated learning for graduate students in the field of education administration.

8. Recommendation for Further Research

8.1 To ensure that the model of work-integrated learning to prepare educational administrators for graduate students in the field of education administration in the maximum efficiency and effectiveness, there should be a study of competency as an innovator in educational administration to be an organization of innovation to catch up with changes.

8.2 There should be the studying of a model using the operational network process to evaluate the basic competency before and after practicum in order to be linked to the desirable characteristics of graduate students who will be educational administrators in the disruptive era and ensure that graduate students in the field of educational administration will have the competencies in accordance with announcement of the Teachers Council of Thailand on accreditation of degree and certificate in education for professional practice for Thailand.

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An impact analysis of a Deposit-Refund System to mitigate hazardous packaging waste in Thai agricultural sector

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Abstract

Hazardous waste could harm human, animal, and ecology system and it has been a critical issue in Thailand for many years. One of the main sources of hazardous waste would come from the agricultural sector such as herbicide and pesticide chemical. In order to cope with these a Deposit-Refund System (DRS) may be a suitable policy to mitigate the waste especially hazardous packaging waste used in the sector. This theoretical work attempted to investigate impacts of the policy on the market including hazardous chemical and agricultural product prices. The findings showed that whenever DRS is imposed in the agricultural sector, the price of hazardous chemical products would increase by the total of the marginal administrative cost of hazardous packaging waste management and the marginal renting cost of keeping hazardous packaging wastes for return. In addition, the price of agricultural products would also increase by the value of administrative cost and renting area cost per unit of hazardous packaging waste. As a result, the policy maker needs to prepare for the rising prices together with the policy implementation.

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

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 & 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.

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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 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 & 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 between deposit rate, refund rate and marginal social cost, the social benefit would be larger than using just a tax or subsidy alone. Palmer, Sigman and Walls [12] and Walls [13] also compared the implementation costs across Tax, Subsidy, and Deposit-Refund System tools for recycle 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 reduce recycle waste by 7.5%. Like Palmer, Sigman and Walls [12], Walls [13], and Oosterhuis, Papyrakis and Boteler [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 recycle 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 0.02 – 0.78 US dollars.

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 [16]. He studied costs and benefits of implementing the Deposit-Refund System to handle beverage containers in Israel. The findings indicated that the average cost of the policy implementation was about $0.038. In the meantime, the benefits from the policy such as lower waste management cost were greater than the cost of the policy implementation for over 35%. On the other hand, the deposit-refund may not be suitable for every case, as claimed by Numata [17]. 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 forfeit their deposit. Consequently, the process of the Deposit-Refund System is not completed which in turn induces a market failure. 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 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 [18].

Regarding the critical issue of hazardous packaging waste management in the Thai agricultural sector, an implementation of Deposit-Refund System policy seems to be viable. However, the statement by Numata [19] about the negative impact of the policy on market failure may need to be taken into account before imposing such policy in Thailand. For this reason, this paper was conducted to examine impacts of the Deposit-Refund System which would be imposed in the agricultural sector in Thailand soon.

2. Objectives

This paper attempted to investigate impacts of the Deposit-Refund System on both the hazardous chemical and agricultural product prices so that the policy maker could implement the policy efficiently. Hence, it would not create burdens on the chemical shops, farmer as well as consumers and become green economy in the future.

3. Methods and Results

To explore effects of DRS which have not been implemented yet in Thailand, the theoretical analysis was obtained. Various theories of producer and consumer were reconstructed by injecting the policy into their decision making of production and consumption, respectively. Thus, this section was divided into 2 parts as follows.

3.1 Hazardous chemical seller's decision making under a constraint of DRS

As the hazardous chemical retailers have to pay for the deposit rate which can be seen as packaging waste tax at this moment, the total revenue of the retailers is then deducted as shown in the equation (1).

$$TR = (p_x - tax)x \tag{1}$$

where TR is a total revenue of retailers, p_x is a hazardous chemical product price, tax is a deposit rate per unit of product, x is the number of hazardous chemical products being sold.

The cost of production (TC) consists of three parts: fixed cost (FC), variable cost (VC) and transaction cost (TX) which represent an opportunity cost of hazardous packaging waste management.

$$TC = FC + VC + TX \tag{2}$$

In addition, the fixed cost is determined as an exogenous variable

$$FC = FC^* \tag{3}$$

The variable cost is then constructed from both wage and packaging costs which could be subsidized by the refund from returning the hazardous packaging waste to the upstream seller.

$$VC = mvc \cdot x + (p_x - sub) \cdot k \tag{4}$$

where mvc is a marginal variable cost, x a number of selling hazardous chemical products, p_k is a hazardous packaging price, sub is a refund rate, and is a number of hazardous packaging waste which equal to a number of selling hazardous chemical products (x) so equation (4) could be rewritten to equation (5).

$$VC = mvc \cdot x + (p_k - sub) \cdot k \tag{5}$$

The transaction cost is a combination of an opportunity cost for returning the packaging waste, a transportation cost and the packaging waste administrative cost.

$$TX = \omega \cdot time_{trv} + c_d \cdot D + CA \tag{6}$$

where ω is a wage rate per hour, $time_{trv}$ is a number of hours spent on the transportation for returning the waste, c_d is the marginal cost of travelling to returning the waste, D is a distance from the site to a seller's shop, CA is an administrative cost for the hazardous waste management which could be calculated from an opportunity cost of administrative time to collect the waste (mac) and using space for keeping the waste until return (mrc). Hence, the TX could be rewritten as follows;

$$TX = \omega \cdot time_{trv} + c_d \cdot D + mac \cdot x + mrc \cdot x \tag{7}$$

Thus, the total cost for a hazardous chemical seller is reconstructed as follows,

$$\begin{aligned} TC \quad = \quad & FC^* + mvc \cdot x + (p_k - sub) \cdot x \\ & + \omega \cdot time_{trv} + c_d \cdot D + mac \cdot x \\ & + mrc \cdot x \end{aligned} \tag{8}$$

As the goal of the hazardous chemical seller is to maximize its profit, the profit function (π_1) is now constructed and derived with respect to x in order to express maximizing conditions as shown in equations (9) – (11).

$$\begin{aligned} \pi_1 \quad = \quad & [(p_x - tax) \cdot x] - [FC^* + mvc \cdot x \\ & + (p_k - sub) \cdot x + \omega \cdot time_{trv} + c_d \cdot D \\ & + mac \cdot x + mrc \cdot x] \end{aligned} \tag{9}$$

$$\begin{aligned} Max[\pi_1 \quad = \quad & p_x \cdot x - tax \cdot x - FC^* - mvc \cdot x \\ & - p_k \cdot x + sub \cdot x - \omega \cdot time_{trv} \\ & - c_d \cdot D - mac \cdot x - mrc \cdot x] \end{aligned} \tag{10}$$

$$(p_x - p_k) + (sub - tax) - (mvc + mac + mrc) = 0 \tag{11}$$

However, in the case that the policy maker imposes DRS with an equal rate between deposit and refund ($tax = sub$), equation (11) is then transformed into equation (12).

$$p_x = p_k + (mvc + mac + mrc) \tag{12}$$

Regarding the competitive market equilibrium, the marginal cost of production must be equal to the price of product at the maximum profit level. Equation (12) needs to be modified by setting $p_x = mc = mvc + p_k$. Equation (13) is now revealed and illustrates the conditions of the market after the DRS is imposed.

$$p_x = mc(mac + mrc) \tag{13}$$

Equation (13) indicates that whenever the government imposes a Deposit-Refund System policy in the Thai agricultural sector, the price of hazardous chemical products would increase. The price increase is equal to the total of the marginal administrative cost of hazardous packaging waste management and the marginal renting cost of keeping hazardous packaging wastes for return.

3.2 Farmer's decision making to use hazardous chemicals under DRS

The total revenue of farmers who use hazardous chemical products in their production depends on the value of product selling and also the value of hazardous packaging waste refunds as shown in equation (14).

$$TR = p_y \cdot y + sub \cdot x_y \tag{14}$$

where p_y is a product price, y is a number of selling products, sub is a refund rate which can be seen as a subsidy for returning hazardous packaging wastes,

x_y is a number of hazardous packaging wastes which depend on y.

The total cost (TC) of agricultural production is a combination of fixed cost (FC), variable cost (VC), and transaction cost (TX) induced by DRS.

$$TC = FC + VC + TX \qquad (15)$$

where FC is an exogenous variable.

$$FC = FC^* \qquad (16)$$

VC is a summation of the product of a marginal variable cost (mvc) and outputs (y), and the product of deposit rate (tax) and a number of packaging waste (k).

$$VC = mvc \cdot y + tax \cdot k \qquad (17)$$

However, the number of packaging waste here is set to be equal to the number of hazardous packaging wastes used in the production so equation (17) has to change to equation (18).

$$VC = mvc \cdot y + tax \cdot x_y \qquad (18)$$

Tx reflects four opportunity costs: 1) returning time loss that is calculated by multiplying wage (ω) and a period of time spent on the returning process ($time_{trv}$), 2) transportation loss that is captured by multiplying a marginal cost of travel (c_d) and a distance of travel (D), 3) administrative loss which is computed by multiplying a marginal cost of packaging waste management (mac) and a number of packaging waste (x_y), and 4) renting area loss that is calculated by multiplying a marginal cost of renting area used to keeping packaging waste before return (mrc) and a number of packaging waste (x_y).

$$TX = \omega \cdot time_{trv} + c_d \cdot D + mac \cdot x_y + mrc \cdot x_y \quad (19)$$

Consequently, the total cost of farmers' production is transformed into equation (20).

$$
\begin{aligned}
TC = \ & FC^* + mvc \cdot y + tax \cdot x_y + \omega \cdot time_{trv} \\
& + c_d \cdot D + mac \cdot x_y + mrc \cdot x_y \qquad (20)
\end{aligned}
$$

Then, the farmer would like to maximize its profit subject to a number of outputs as shown in equations (21) – (23).

$$
\begin{aligned}
\pi_2 = \ & [p_y \cdot y + sub.x_y] - [FC^* + mvc \cdot y \\
& + tax \cdot x_y + \omega \cdot time_{trv} + c_d \cdot D \\
& + mac \cdot x_y + mrc \cdot x_y] \qquad (21)
\end{aligned}
$$

$$
\begin{aligned}
Max[\pi_2 = \ & p_y \cdot y + sub \cdot x_y - FC^* - mvc \cdot y \\
& - tax \cdot x_y - \omega \cdot time_{trv} - c_d \cdot D \\
& - mac \cdot x_y - mrc \cdot x_y] \qquad (22)
\end{aligned}
$$

$$p_y - mvc + (sub - tax - mac - mrc) \cdot mx_y = 0 \quad (23)$$

In the case of imposing deposit rate and return rate equally, the tax variable must be equal to the sub variable in equation (23). Thus, it is transformed into equation (24).

$$p_y = mvc + (mac + mrc) \cdot mx_y \qquad (24)$$

Moreover, at the market equilibrium, the marginal variable cost here is the same as the marginal cost of production so equation (24) is rewritten to be equation (25).

$$p_y = mc + (mac + mrc).mx_y \qquad (25)$$

Equation (25) could be interpreted that when DRS is imposed on the Thai agricultural sector, the price of agricultural products would increase. The incremental price is equal to the value of administrative cost and renting area cost per unit of hazardous packaging waste.

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 counties 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. For this reason, the government may impose DRS in the agricultural sector in the near future. We found that whenever DRS is imposed in the agricultural sector, the price of hazardous chemical products would increase by the total of the marginal administrative cost of hazardous packaging waste management and the marginal renting cost of keeping hazardous packaging wastes for return. In the meantime, the price of agricultural products would also increase by the value of administrative cost and renting area cost per unit of hazardous packaging waste. These incremental prices of both hazardous chemical products and agricultural products would be rather reallocated between the producers and consumers due to the market mechanism. Hence, the policy maker needs to prepare for the rising prices together with the policy implementation in order to make a sustainable economy.

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The development of online lessons to enhance practical skills with problem-based learning on microcontroller Arduino for undergraduate students

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Abstract

The purposes of this research were as follows: 1) to develop the online supplementary lessons to enhance practical skills with problem-based learning on Microcontroller Arduino for undergraduate students, 2) to evaluate the quality of the online supplementary lessons, 3) to compare the academic achievement of the learners before and after learning, and 4) to evaluate the satisfaction of the learners towards the online supplementary lessons. The sample group were 30 first-year undergraduate students of Computer Education of Nakhon Pathom Rajabhat University who enrolled in the 2/2019 semester selected by purposive sampling. The research apparatuses were as follows: 1) the online supplementary lessons on Microcontroller Arduino, 2) the online supplementary lessons' quality assessment forms, 3) pretests and posttests, and 4) the satisfaction assessment forms of the learners. The statistics used in data analysis were mean, standard deviation, and t-test statistics. The research found that 1) the online supplementary lessons to enhance practical skills with problem-based learning on Microcontroller Arduino for undergraduate students of Computer Education of Nakhon Pathom Rajabhat University had the quality of content and media production at a very good level ($\overline{X}$ = 4.53, S.D. = 0.57), 2) the academic achievement of the learners after learning was statistically significantly higher than before learning at 0.05, and 3) the overall satisfaction of the learners was at the highest level ($\overline{X}$ = 4.52, S.D. = 0.59).

Keywords: Arduino, microcontroller, online lesson, practical skills, problem-based learning

1. Introduction

Nowadays, Internet of Things (IoT) has been one of the life essentials as we connect to the internet more, we are more confident to control in major parts of life such as Smart Home or Smart Farming [1]. The development of IoT had been spreading into several aspects especially in industrial field which promotes value for the transportation business. Electronics could be connected both wire and wireless via Bluetooth that enhanced data processing that has developed the capabilities of the device to be smaller but more effective as well as designing IoT up to date products and support the convenience for users to use more easily [2]. IoT technology that will be applied will be divided into 3 sections; 1) Technology makes everything aware of information as interacting or approaching such as sensor that detects and reacts the input that are light, movements, humidity, pressure, etc. 2) the technology allows everything to communicate for example embedded system that was found in electric appliances by using the chip that follow the instruction or using the Microprocessor as well as Bluetooth, Low Power Wide Area Network (LPWAN) etc. These is the low energy consuming but provides a wide range of connection and 3) Technology assists everything to process information such as Cloud Computing which allows processing power storage unit and various online programs from service providers and the most known is Big Data Analytics, a process of analyzing large data to find the link patterns of those data while the results of the analysis can lead to effective business planning [3].

Microcontroller is the most famous used in electric appliances by embedded itself inside the appliances such as automatic washing machine, electric oven, microwave oven, air conditioning, these specify the temperature factor. While Arduino is to use various IC microcontroller in aspects of using C language together that was written to enable the operation of different microcontrollers as well as can use the same code. The

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project has released a variety of experimental boards in order to conduct with IDE itself Arduino as the most famous platform to operate both hardware and software due to the low cost of creating circuits in which the microcontroller operation must consist of 2 components; Hardware - machine and Software - programming platform of Arduino. The design is to offer a user-friendly without having any programming intellectual but only chosen Arduino and its feature. [4]

Arduino was developed in Ivrea, northwestern Italy in 2005 by Massimo Banzi and David Cuartielles. They intended to create cheap microcontroller devices that students can access then it was bought to be the owner. The small factory in this city was used as the first production of the Arduino board, the project name Arduino of Ivrea Arduino used to develop electronic devices prototype that designed to be easy to use, both hardware and software. The target consumers are inventors, designers who are interested in inventing innovations or creative work. In addition to the price of the device being compared to other microcontrollers on the market, Arduino can also be developed by a free program as an Open Source condition. [5]

Students majoring in Computer Education, Nakhon Pathom Rajabhat University enrolled in the second semester of the academic year 2019 had been assigned to study Innovation and Information Technology Course for Educational Communication and Learning subject regarding to the basic foundation of circuit system and other concern devices applying with the theory and emphasis on the practical way. This is to combine the practical and theory together further the boundaries of classroom.

The National Education Act of A.D. 1999, Chapter 4, Educational Management Guidelines, Article 24 describes the organization of the learning process. The educational institutions and related agencies should arrange the content and activities in accordance with the aptitude and interest of the learners, taking into account differences between people. Thinking process, management, coping, and applying knowledge to prevent and solve problems, encouraging instructors to organize the educational environment media and facilities for the learners to learn. Thus, teaching and learning are necessary to change the teaching and learning process that is based on teachers as the center for transferring knowledge by lecturing to organizing the learning process in accordance with the principles of the National Education Act, especially section 24 group 2 regarding practicing thinking and management process, encountering circumstances, and adapting knowledge to solve problem and section 24 group 3 regarding organizing activities for learners to learn from real experiences, love reading, and continuous curiosity to learn. [6]

The problem based is the cooperative learning in 21st century that emphasis center learner model. The learner will be group into 5-8 students per 1 teacher or another facilitator. This model begins with a significant problem as to simulate the future real world situation without a prior preparation; scenario or problem. In order to find reason and stimulus students to practice thinking and reasoning to explain by attempting to solve basic problems by using the same basic knowledge. Everyone has to set a base resolution along with considering and establishing the objectives of the study to find necessary knowledge. Along with considering and establishing the objectives of the study to find necessary knowledge to help to prove the hypothesis. After that, the group of students will disperse to study with various methods according to the objectives that have helped each other and then bring the newly added information. According to the objectives that have been set aside and then bring new additional information are reversed back to help summarize the assumptions to solve problems. [7]

Online lessons (e-learning) is the application of technology in teaching and learning by using multimedia technology to create content and produce teaching materials according to the needs of the students through online lessons which will make the learners to be able to access to the content and understand more easily and form learning process all the time.[8] Using online lessons increases motivation for learners and it is an exotic experience, a virtual addition and inspire learners to learn, do exercises and activities. It conveys content in the form of images, animations, text graphics and sound. There is also a direct interaction between the computer and the learner in order to create motivation in learning, making students more excitement and fun. [9]

According to the importance and the problems mentioned above, the researcher therefore had an idea to enhance learning achievement by using online skills media on the initial Microcontroller Arduino cope with problem based management. Students majoring in Computer Education, Nakhon Pathom Rajabhat University who enrolled in the second semester of the academic year 2019 were assigned to study Computer Educations Subject as they were required to create media for learning skills in connecting the sensor circuit to the Arduino uno r3 board and can write programs to control various devices and solve the problems that the teacher set up. The students can study by themselves or find more from the website, with instructors to offer an advice. This process would help students to think and analyze systematically as well as understand the functional design enable learners to create knowledge by themselves in the future.

2. Objective

1. To develop an online lessons skills development on Microcontrollers Arduino basic with problem-based learning on Innovation and Information Technology Course for undergraduate students.

2. To evaluate the quality of the online lessons.

3. To compare the learning achievement of learners before and after learning with the online lessons on the Microcontroller Arduino basic with problem-based learning for undergraduate students.

4. To assess learners' satisfaction towards the online lessons on Microcontrollers Arduino basic with problem-based learning for undergraduate students.

3. Hypothesis

1. The quality of the media enhances the online lessons of the initial Microcontroller Arduino basic that has been evaluated by 5 experts for undergraduate students is in good level.

2. Achievement of learners before and after learning with the online lessons on the Microcontroller Arduino basic with problem-based learning for undergraduate students gains a higher value than before learning with statistical significance at .05.

3. Students' satisfaction towards the online lessons on the initial Microcontroller Arduino basic with problem-based learning for undergraduate students is in a high level.

4. Scope of the Research

1. Research plan

This research is an experimental research. The researcher used the research plan of one group pretest-posttest design which has the details as follows:

Table 1. One group pretest-posttest design.

Samples Group	Pretest	Experimenting	Posttest
E1	T1	X	T2

E1 = Samples Group
T1 = Pretest
X = Experimenting
T2 = Posttest

2. Population and sample

2.1 The population in this research was 360 students of Computer Educations who enrolled in the academic year 22/019.

2.2 The samples in the research were 30 of first year students majoring in Computer Education. Students enrolled in academic year 2/2019, and were selected by simple random sampling.

3. Variables to be studied

3.1 The independent variable was the online lessons on the initial Microcontroller Arduino basic with problem-based learning for undergraduate.

3.2 The dependent variables included academic achievement and the satisfaction of learners.

4. The content was the Innovation and Information Technology Course for undergraduate students; in this research, the researcher has designed the lessons in practice on Microcontroller Arduino basic to conduct 3 units of experiment, which are;

4.1 Connection of Microcontroller Arduino to LED Lamp.

4.2 Connecting the Microcontroller Arduino with soil moisture sensor.

4.3 Connection of Microcontroller Arduino to I2C LCD Display.

5. Methodology

This research study was the development of the online lessons on Microcontroller Arduino with problem-based learning of students majoring in Innovation and Information Technology Course for undergraduate students. The researcher conducted the research according to the ADDIE Model [10] as follows:

1. Analysis Stage: the researcher conducted the analysis as follows: Studied courses and course descriptions on Innovation and Information Technology Course, classified activities and analyzed the content and objectives of the course. Selected content, consisting of 3 units of study related to be developed study the problem-based learning and learning model, applied the design of online teaching and learning activities and studied the technology to be used in media development, including Webhost, Atom, Adobe Photoshop CS6, Camtasia 9, and Google from websites, documents as well as related research.

2. Design stage: the researcher carried out the design as follows:

2.1 Designed content learning units, quality assessment forms of the online lessons, the tests before and after learning, problem-based learning activities, and satisfaction assessment forms of learners.

3. Development stage: the researcher developed the followings:

3.1 Developed online skills and quizzes using webhost, Atom, Adobe Photoshop CS6 and Camtasia 9, and brought webhost online learning materials.

3.2 Developed a media quality assessment form to enhance the online skills of the Microcontroller Arduino Introduction to content and media production techniques. Presented to 5 experts for quality evaluation.

3.3 Developed a test before class and after class.

3.3.1 The researcher created 50 items, with 5 experts evaluating the accuracy of the questions (IOC). The results showed that the test passed the criteria of 44 items with the IOC = 0.83 and the test was applied to find the difficulty and the power of discrimination.

3.3.2 The researcher brought 44 items to find the difficulty and the power of classification with the second year students in the Computer Education. It was found that the test has passed 35 items long criteria with the difficulty (P) = 0.65 and the classification

power (D) = 0.48 and the test to find confidence in the next order.

3.3.3 The researcher selected 30 items from 44 items to find the reliability of the whole set of tests. It was found that the test had a reliability of 0.72, which is in the appropriate criteria. This shows that this set of tests can be used in research

3.4 Developed students' satisfaction assessment form using a rating scale with5 levels [11];

5.00 = the highest level
4.00 = high level
3.00 = medium level
2.00 = low level
1.00 = the lowest level

4. Implementation: the researcher conducted the experiment and applied as follows:

4.1 Explained how to access to online skills enhancement media and the problem-based learning

4.2 Required students to do a pretest before study.

4.3 Assigned learning and work, issues, discuss knowledge learned with classmates and teachers.

4.4 Required students to do the posttest after study.

4.5 Required students to do a questionnaire to assess the satisfaction of the learners about using online learning skills about Microcontrollers Arduino basic with problem-based learning for student studying Innovation and Information Technology Course for undergraduate students.

5. Evaluation: the researcher conducted the evaluation as follows:

Analyzed the data obtained from the experiment and to find the statistical values which are mean, standard deviation and t-test statistics, summary of the experiment results and writing a research report.

6. Results

1. The results of the development of online lessons on the initial Microcontrollers Arduino with problem-based learning for undergraduate students Consists of lessons as shown in Fig. 1 – Fig. 6.

Figure 1: Main menu.

Main Menu consists of 6 items as follows:
1) Instructions for using lessons
2) Pre-test

3) Post-test
4) Lab 1: Connection of Microcontroller Arduino to LED Lamp
5) Lab 2: Connecting the Microcontroller Arduino with soil moisture sensor
6) Lab 3: Connection of Microcontroller Arduino to I2C LCD Display

Instructions describe doing pretests, posttests, and 3 chapters' contents.

Figure 2: Instructions for using lessons.
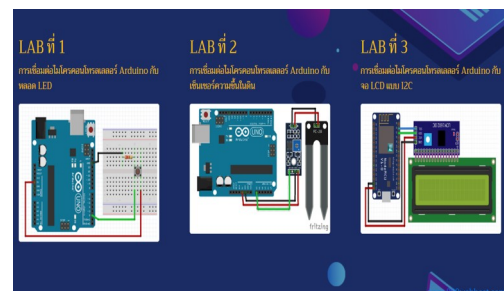
Figure 3: lesson.

Figure 4: Lab 1: Connection of Microcontroller Arduino to LED Lamp.

Each lesson has the teaching video for the learners to be able to learn and practice by themselves.

2. The results of the online lessons quality assessment are shown in Table 2.

From Table 2, it was found that the quality of the online lessons, evaluated by 5 experts was an average of 4.53 and a standard deviation of 0.57.

3. The comparison of learning achievement of students before and after learning with online lessons

Figure 5: Lab 2: Connecting the Microcontroller Arduino with soil moisture sensor.
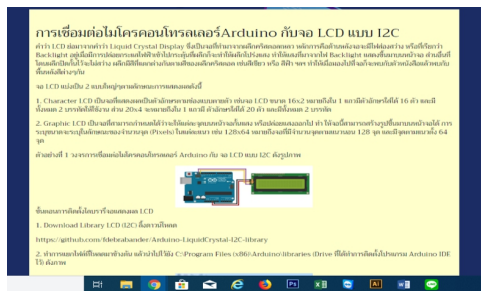
Figure 6: Lab 3: Connection of Microcontroller Arduino to I2C LCD Display.

Figure 7: Teaching Video.
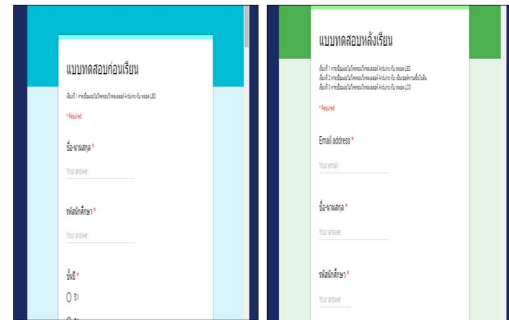
Figure 8: Pretest and Posttests.

Table 2. The results of the online lessons quality assessment.

Evaluation	Results		Level
	Average	S.D.	
Content	4.43	0.59	Good
Media Production	4.62	0.54	Very good
Total	**4.53**	**0.57**	**Very good**

on the initial Microcontroller Arduino with problem-based learning for undergraduate students is presented below in Table 3.

Table 3. The comparison of learning achievement of students.

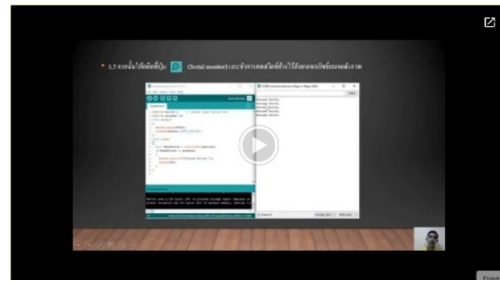| Test score	N	Total Score	$\overline{X}$	S.D.	t	sig
Before learning	30	30	15.20	3.80	5.47	.000**
After learning	30	30	26.67	1.93		

** With statistical significance at the level of .05

From Table 3, it was found that learners' learning through online lessons had academic achievement of post study as (= 26.67, S.D. = 1.93) which is higher than pre study as (= 15.20, S.D. = 3.80). Moreover, the statistical significance was at the level of .05 which is in accordance with the set hypothesis.

4. The results of the assessment of students' satisfaction towards the online lessons are shown in Table 4.

Table 4. The results of the assessment of student satisfaction.

Question item	Results		
	$\overline{X}$	S.D.	Level
Contents			
1. Content consistent with purposes	4.67	0.57	highest
2. Clear explanation	4.53	0.37	highest
3. Suitable sequence of content	4.30	0.49	high
4. Suitable language	4.06	0.69	high
5. Clear questions and answers	4.83	0.59	highest
Average	**4.48**	**0.54**	**high**
Techniques			
6. Font, size, and color of letters	4.43	0.67	high
7. Background	4.23	0.68	high
8. Sound and animation	4.55	0.96	highest
9. Interaction with users	4.96	0.68	highest
10. Beauty	4.54	0.47	highest
Average	**4.54**	**0.69**	**highest**
Problem-based Learning			
11. Various activities	4.65	0.56	highest
12. Interesting learning	4.96	0.78	highest
13. Learners take part in assessment	4.56	0.31	highest
14. Sharing experience with friends and instructor	4.13	0.68	high
15. Can study by yourself all the time	4.46	0.50	high
Average	**4.55**	**0.56**	**highest**
Total	**4.52**	**0.59**	**highest**

From Table 4, it was found that the students were satisfied with the highest level ($\overline{X}$= 4.52, S.D. = 0.59)

when considering each aspect, it was found that the content was at a high level of satisfaction ($\overline{X}$= 4.48, S.D. = 0.54).Furthermore, the technical production was at the highest level ($\overline{X}$= 4.54, S.D. = 0.69) and the problem-based learning and activities were also at the highest level ($\overline{X}$= 4.55, S.D. = 0.56).

7. Conclusions

1. The quality of the media enhancing the online skills of the initial Microcontrollers Arduino with problem-based learning on Innovation and Information Technology Course for undergraduate students evaluated by 5 experts was at a very good level with an average of .4.53 and a standard deviation of 0.57 which is in accordance with the assumption.

2. Achievement of learners before and after learning with online lessons about Microcontrollers Arduino, basic with problem-based learning on Innovation and Information Technology Course for undergraduate students had higher academic achievement after studying with statistical significance at the level of.05 in accordance with the assumptions set.

3. Overall, students' satisfaction with the online lessons on the initial Microcontroller Arduino with problem-based learning on Innovation and Information Technology Course for undergraduate students, was the highest level ($\overline{X}$=4.52, S.D.=0.59) which is in accordance with the hypothesis set.

8. Disscussion

1. Learning achievement of learners after learning by online lessons had higher academic achievement than before learning with statistical significance at the level of .05 in accordance with the assumptions set. That is because the research has passed the evaluation process of media quality from 5 experts which was suitable before being applied in the class. The media quality included the online lessons consisting of content, practice, that are colorful and able to attract the attention of learners, and activities to practice which are agreeable with the research of Kriangsak Ploysang [12] who studied learning achievement in language courses and communication using problem-based learning, found that the learning achievement in teaching language courses and communication that use problem-based learning as the base after learning is higher than before study with statistical significance at the level of .0.

In addition, it is also in line with the research of kinnaree Chian, Piya Supavarasuwat, Wisult Sunthonkanokpong and Sunti Tuntrakool [13] who conducted the research on the internet based tutorial lesson on cable TV, found that when the pretest and posttest scores of the students were compared, the average score of posttest was statistically higher than that of the pretest at .01 level.

2. Learners' satisfaction with online skills enhancement media titled Microcontrollers Arduino basic with problem-based learning on Innovation and Information Technology Course, was at the highest level with an average of 4.52 and a standard deviation of 0.59 as online lessons enabled students to learn anywhere and anytime. It made learners to be more comfortable in learning and understand contents by themselves. Each content in each chapter was suitable and made students enjoyable in learning. The findings are agreeable with the research of Zacharis [14] as learners can elastically work together resulting in the learners to have good quality works, better records, and satisfaction towards teachings.

9. Recommendation

1. General Recommendation

1.1 Learners have better academic achievement due to the learning by using online skills enhancing media about Microcontrollers Arduino with problem-based learning on Innovation and Information Technology Course. The researcher thinks that this online skill-enhancing media should be used for other learning management, including project-based learning.

1.2 Online lessons can help learners practice. This can increase skill which is suitable for practical subjects which can practice through online lessons at any time but may add activities or exercises or more diverse games to meet the different learning needs of learners. In addition, exercises that are diverse should be added. Importantly, it must be suitable with the content, objectives and needs of learners.

2. Suggestions for further research

2.1 The online lessons from this research should be adopted and incorporated into online lessons of a subject in order to enhance and develop teaching activities more effectively by using technology.

2.2 The online lessons from this research should be developed in order to be able to be used on the online platform of a portable device.

2.3 Should be a sound of motion picture that have video clips in order to be more interesting.

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Biological transformed cannabinoids bee pollen: A symbiosis approach on *Apis mellifera* raising protocol in *Cannabis sativa* L. (Hemp) cultivar in Samoeng District, Chiang Mai, Thailand

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Abstract

Honey bees (*Apis mellifera*) and Hemp plants (*Cannabis sativa* L.) have been recognized as boosters in the world economy. Hemp pollens collected by honey bees for their nutrients and cannabinoids discrete from cannabis plants have not been synergized in business management. A symbiosis approach was adopted in this novel experimental method. This research aimed to investigate the presences of Cannabinoids (CBD, THC and CBN) via a prototype of bee-raising protocol with the different artificial fed supplements, foraging on the hemp plantation to collect hemp pollens. Theoretically, in-hived stored hemp pollen shall embrace active compounds as being abundance in hemp plants, thru biological transformation process. In the field experiment, seed production hemp cultivated in Samoeng District, Chiang Mai was fully covered by mosquito net to confine honey bees during male flowering. The extraction of those cannabinoids of in-hived stored pollen samples and their contents were conducted by GC-MS technique. A repeated measure ANOVA model was conducted for statistical analysis. The experimental research results indicated the first ever found of cannabinoids presented in in-hived stored pollen samples of all treatments. The statistical analysis among all treatments contained different means of detected Cannabinoids (CBD, THC and CBN) contents, which were statistically significant (P-value < 0.05) where the significant level of 95%. The results were remarkable as shown due to presence of CBD, THC and CBN, as bioactive compounds, in in-hived honey bee pollens that would enlighten an opportunity in managing bee as hemp plantation either for further academic or business purposes.

Keywords: *Cannabis sativa* L. (Hemp), cannabinoids, *Apis mellifera* (Honey bee)

Article history: Received 8 April 2020 Accepted 19 May 2020

1. Introduction

The phytochemical constituents such as high potency cannabinoids have been drawing the world attentions. Many investigations of pharmaceutical and medicinal properties of *Cannabis sativa* L. is drawing attentions from scientist worldwide [1]. Cannabinoids, i.e. Δ9-tetrahydrocannabinol (THC), Cannabidiol (CBD) and Cannabinol (CBN) have been studying for future uses. Since the discovery of cannabinoid receptors and the Endo-cannabinoid System (ECS) in human's immune cells in the mid of 20th century [2 – 5] enhance wider and deeper researches in many countries including Thailand. Recent studies have documented the importance of hemp pollen in support-

ing a diverse community of honey bees during periods of floral resource scarcity [6, 7]. A mass flowering hemp crops can support pollinator populations foraging [8, 9]. The presence of cannabinoids, particularly psychoactive Δ9-tetrahydrocannabinol (THC) and Cannabinol (CBN) in hemp pollen however does not likely to have an impact on bee development due to the lack of cannabinoid receptors in insects [10]. The research aimed to investigate Cannabinoids in *Cannabis sativa* L. (hemp) plant being transferred by means of honey bee raising protocol with the different artificial fed supplements into in-hive stored pollen using a symbiosis approach cum a biological transformation technique. The raising bees need to have sufficient nutrient foods combining of proteins collected from plant pollens and carbohydrates from plant nectars. Since hemp plants are naturally lack of sufficient

nectar to maintain bee colony healthy, artificial supplements in forms of diluted honey and diluted sugar syrup were adopted in the separated treatments.

2. Material and method

2.1 Field experiment

A total of 9 hives of raising honey bees were moved to 5 Rai hemp plot where hemps were planted for seed and fibre production in Baan Khong Khark Luang, Samoeng, Chiang Mai, Thailand (Latitude: 18°53'45.75" North and Longitude: 98°42'23.31" East). Bees were raised in beehives with monitoring system. Each group of 3 beehives were distinguished into 3 treatments (Ts) as T1- kept in netted hemp plot and in-hive drop-fed with 1:1 diluted honey; T2- kept in netted hemp plot and in-hive drop-fed with 1:1 diluted sugar syrup; and T3- kept outside netted hemp plot without any artificial feeding as a control that let bees free forage in opened hemp field next to the netted hemp plot. The differences of bee's nectar supplement consumed, can be influenced to the quality of bee product yields.

2.2 Sample collection process

The in-hive-stored Pollens, during the male flowering peak, were collected from brood frames into prepared and sterilized vials on every other days (on September 14, 16 and 18 between 13.00 and 16.00 hours in volumes of approximately 10 grams from each hive for sufficient laboratory investigation.

2.3 Laboratory materials and methods

Using Gas Chromatography-Mass Spectrometry Method (GC-MS) [11 – 13] was conducted by the certified Central Laboratory (Thailand) Co., Ltd. (Chiang Mai Branch): CLT. **Instruments: Gas Chromatograph/Mass Spectrometry Detector (GC/MSD) for cannabinoids: Gas chromatography**: Agilent technologies made in China; Model 6890 N, Oven 100 °C hold 1 min, 10 °C/min to 300 °C hold 9.0 min., Post time 5 min. at 330 °C, Total run time 30 min., Helium carrier gas flow 1.0 mL/min, Column DB 5MS Agilent technologies made in USA. 0.25 mm × 30m × 0.25 micron of film thickness., Inlet split 20:1 volume of injection 1 uL, Inlet temperature 280 °C, Auxiliary temperature 280 °C; **Mass spectrometer detector**: Agilent technologies made in USA., Model 5973 inert, Scan mode 40 – 500 m/z, MS Quadrupole temperature 150 °C, MS Source temperature 230 °C; **Database Agilent technologies USA**: Wiley version 9; **Basic instrument**: Ultrasonic bath: BRANSON 3510 USA., Vortex mixer: Genie 2 USA., Water bath: Memmert WNE21 Germany, Freezer -20 °C: Sanyo Japan; **Reagent**: Hexane: (HPLC Grade) Labsan Ireland.; **Cannabinoids standard THC/CBD/CBN**: RESTEX (34014) USA. Sample accurate weight of 0.05xx – 0.10xx grams.

2.4 Statistical method

According to the field experimental design and the laboratory method as described in prior sessions, a set of data was designed in 3 different treatments (3 bee hive replicates in each treatment) and in-hive stored bee pollen samples were repeatedly measured or collected in 3 time-points [14]. The harvesting time-point crucially reflects on a maturity of quality bee product yields [15]. Therefore, the reliability of a data set was tested by using replicated bee hive Standard Deviations (SDs) dispersed relative to replicated bee hive Means. Finally, the repeated measures ANOVA technique was separately analysed on each set of detected CBD, THC and CBN data [16].

3. Results

3.1 Detections of cannabinoids (CBD, THC and CBN) in in-hive stored bee pollen samples

Using the repeated measures ANOVA model. The laboratory results shown the detected CBD, THC and CBN comparison by each measuring time-point of the sample collections shown in Table 1, 4 and 7, respectively. Means and Standard Deviations (SDs) of each treatment's replication as shown in Table 2, 5 and 8, respectively, were statistically analysed below.

Figure 1: Experimental *Cannabis sativa* L. cultivar and foraging honey bee.
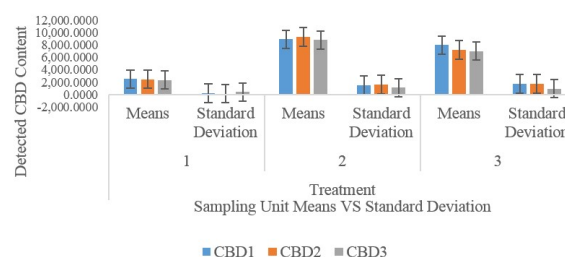

Figure 2: Observation on the measured values of detected CBD content (CBD1-3 measuring time-points) related to the sampling unit (each of 3 replicated beehives) means.

3.2 Detected cannabidiol (CBD) content (mg/kg) by treatment (experimental unit) classification.

As seen in above Table 1, 2 and Fig. 2, the datasets of detected CBD content were observed with the Stan-

Table 1. Detected cannabidiol (CBD) content (mg/kg) classified by treatment (experimental unit).

Treatment	Replication	Measure 1	Measure 2	Measure 3
1	1	2,348	2,335	1,954
(1:1 diluted honey fed)	2	2,703	2,600	2,428
	3	2,426	2,445	2,728
2	1	9418	10,903	10,152
(1:1 diluted sugar syrup fed)	2	10,209	9,470	8,021
	3	7,252	7,663	8,482
3	1	6,060	6,824	7,288
(Controlled)	2	8,786	5,768	6,005
	3	9,180	9,166	7,777

Table 2. Standard Deviation on the measured data of detected CBD content dispersed to the sampling unit (each of 3 replicated beehives) mean.

| Measure # | Treatment | | | | | |
| | 1 (Diluted honey fed) | | 2 (Diluted sugar syrup fed) | | 3 (Controlled) | |
	Means	Standard Deviation	Means	Standard Deviation	Means	Standard Deviation
CBD1	2,492.3333	186.5646	8,959.6667	1530.8541	8,008.6667	1699.0542
CBD2	2,460.0000	133.1353	9,345.3333	1623.5936	7,252.6667	1739.0852
CBD3	2,370.0000	390.2461	8,885.0000	1121.2034	7,023.3333	915.1679

Table 3. Analysis of variance of detected cannabidiol (CBD) content.

Sources of Variation	Sum of Squares	Degrees of Freedom	Root Means Square (RMF)	$F_{(1,2\&3)}$	P-value
Experimental Unit (Treatment)	214,219,297.556	2	107,109,648.778	39.906	<0.0009
Discrepancy	16,104,120.444	6	2,684,020.074		
Sum of between Groups	230,323,418.00	8			
Time of Measure	722,644.222	2	361,322.111	0.422	0.665
Time of Measure * Exp. Unit	1,262,698.889	4	315,674.722	0.369	0.826
Discrepancy	10,276,331.556	12	856,360.963		
Sum of Within Group	12,261,674.67	18			
Sum Total	**242,585,092.67**	**26**			

dard Deviation of each replicated bee-hive in all treatments are dispersed closely to their means, in the same dispersion pattern. Therefore, they were statistically reliable for further statistical analysis of ANOVA.

3.3 Analysis of variance of detected cannabidiol (CBD) content

From the test, it was found that

Where F_1 = 39.906 It could be concluded that each experimental unit contains different means of detected CBD, P-value < 0.0009. When a pair test was given, the findings were that none of means differences of experimental unit 2 and 3 was found with greater means than experimental unit 1.

Where F_2 = 0.422 It could be concluded that none of different means was found in each measure of detected CBD, P-value = 0.665.

Where F_3 = 0.369 It could be concluded that none of different interaction within measure was found with experimental unit, P-value = 0.826.

Where the significant level in this experiment = 95%

The findings could be interpreted that among 3 different treatments, as the above statistical results showed; among the group of treatments, each treatment had different means of detected CBD which

is statistically significant difference (P-value < 0.05). While none of the different means within each group revealed no statistically significant difference (by each measure and within each treatment P-value > 0.05). Therefore, measured data within a group of treatments were the same means of detected CBD. When comparing average means among all treatments (illustrated in Fig. 3 below); detected CBD content of treatment 2 (with diluted syrup fed and confined bees) and controlled treatment 3 (without feeding, with free foraging) were greater than treatment 1 (with diluted honey fed and confined bees). It was noticeable that under the same protocol of bee raising in order to manage a honey bee colony most ready for foraging *Cannabis sativa* L. (hemp); the artificial feeding with carbohydrate source (nectar) was influential in CBD content contained in bee produce yields.

3.4 Detected Δ9-tetrahydrocannabinol (THC) content (mg/kg) by treatment (experimental unit)

According to the observation on the measured values of detected THC content related to the means of each replicated hives of each treatment (Table 4, 5 and Fig. 4), the dataset of detected THC content was dispersed closely relative to their means in the same dispersion pattern. Therefore, these measured data set

Table 4. Detected Δ9-tetrahydrocannabinol (THC) content (mg/kg) classified by treatment (experimental unit).

Treatment	Replication	Measure 1	Measure 2	Measure 3
1	1	8.69	16.92	14.56
(1:1 diluted honey fed)	2	17.04	12.19	16.17
	3	17.46	14.41	17.05
2	1	8.62	7.75	2.75
(1:1 diluted sugar syrup fed)	2	3.32	1.05	1.00
	3	1.72	6.95	7.53
3	1	1.38	1.08	1.00
(Controlled)	2	4.50	3.51	1.00
	3	1.85	1.00	1.00

Table 5. Standard deviation on the measured data of detected THC content dispersed to the sampling unit (each of 3 replicated beehives) mean.

Measure #	Treatment					
	1 (Diluted honey fed)		2 (Diluted sugar syrup fed)		3 (Controlled)	
	Means	Standard Deviation	Means	Standard Deviation	Means	Standard Deviation
THC1	14.3967	4.9466	4.5533	3.6116	2.5767	1.6822
THC2	14.5067	2.3665	5.2500	3.6592	1.8633	1.4266
THC3	15.9267	1.2627	3.7600	3.3801	1.0000	0.0000
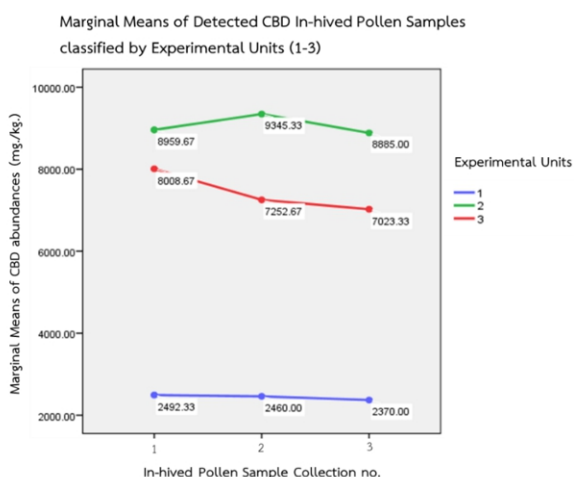
Figure 3: Means of detected Cannabidiol (CBD) illustrated by treatment (experimental unit).

Figure 4: Observation on the measured values of detected THC content (THC1-3 measuring time-points) related to the sampling unit (each of 3 replicated beehives) means.

of detected THC contents are statistically reliable for the next statistical analysis of the Repeated Measures ANOVA test.

3.5 Analysis of variance of detected Δ9-tetrahydrocannabinol (THC) content

From the test, it was found that

Where $F_4 = 47.787$ It could be concluded that each experimental unit contains different means of detected THC, P-value ¡ 0.0009. When a pair test was given, the findings were that none of the means differences of experimental unit 2 and 3 was found with lesser means than experimental unit 1.

Where $F_5 = 0.034$ It could be concluded that no different means were found in each measure of detected THC, P-value = 0.967.

Where $F_6 = 0.347$ It could be concluded that none

of different interaction within measures was found with experimental units, P-value = 0.841.

Where the significant level in this experiment = 95%

It could be interpreted that among 3 different treatments, as the above statistical results showed; among the group of treatments, each treatment had different means of detected THC which is statistically significant difference (P-value < 0.05). While none of the different means within each group showed no statistically significant difference (by each measure and within each treatment, P-value > 0.05). Therefore, measured data within a group of treatments had the same means of detected THC. When comparing average means among all treatments (Fig. 5); detected THC contents of treatment 2 (with diluted syrup in-hive fed and confined bees) and controlled treatment 3 (without feeding, with free foraging bees) were less than treatment 1 (with diluted honey in-hive fed and confined bees). Detected THC contents in nominal terms (mg/kg) were much less than those of CBD contents, comparatively caused by hemp plants are naturally less THC content.

Table 6. Analysis of variance of detected Δ9-tetrahydrocannabinol (THC) content.

Sources of Variation	Sum of Squares	Degrees of Freedom	Root Means Square (RMF)	$F_{(4,5\&6)}$	P-value
Experimental Unit (Treatment)	865.055	2	432.528	47.787	<0.0009
Discrepancy	54.307	6	9.051		
Sum of between Groups	919.36	8			
Time of Measure	0.528	2	0.264	0.034	0.967
Time of Measure * Exp. Unit	10.916	4	2.729	0.347	0.841
Discrepancy	94.467	12	7.872		
Sum of within group	105.91	18			
Sum Total	**1,025.27**	**26**			

Table 7. Detected cannabinol (CBN) content (mg/kg) classified by treatment (experimental unit).

Treatment	Replication	Measure 1	Measure 2	Measure 3
1	1	1.00	1.35	1.00
(1:1 diluted honey fed)	2	1.02	0.00	1.00
	3	0.00	1.00	1.00
2	1	1.60	2.00	2.26
(1:1 diluted sugar syrup fed)	2	1.34	1.80	2.18
	3	1.30	1.03	1.00
3	1	1.13	1.68	1.69
(Controlled)	2	1.84	1.68	1.23
	3	1.69	1.69	1.00
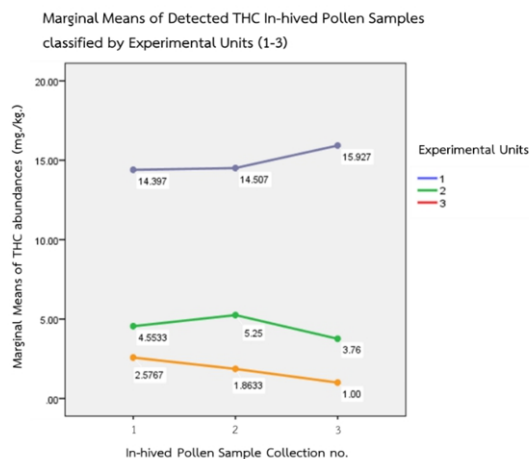
Figure 5: Means of detected Δ9-tetrahydrocannabinol (THC) illustrated by treatment (experimental unit).

3.6 Detected cannabinol (CBN) content (mg/kg) by treatment (experimental unit) classification

The above Table 7, 8, together with Fig. 6 showed that the dataset of detected CBN content was dispersed closely relative to their means, as in the same dispersion pattern. As a result, statistically reliable data set was confident for further statistical analysis of the repeated measures ANOVA test.

3.7 Analysis of Variance of detected cannabinol (CBN) content

From the test, it was found that

Where $F_7 = 6.290$ It could be concluded that each experimental unit contains different means of detected

CBN, P-value = 0.034. When a pair test was given, the findings were that the Experimental units 2 and 3: means did not differ. Experimental units 1 and 3: means did not differ. Experimental unit 2: means was found with greater than those of experimental unit 1

Where $F_8 = 0.392$ It could be concluded that no different means were found in each measure of CBN, P-value = 0.684.
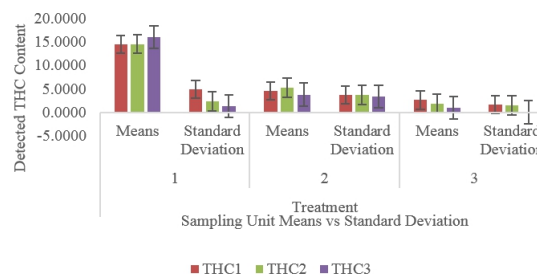
Where $F_9 = 0.674$ It could be concluded that no different interaction within measures was found with experimental units, P-value = 0.623.

Where the significant level in this experiment = 95%

It could be interpreted that among 3 different treatments, as the above statistical results showed; among the group of treatments, each treatment had different means of detected CBN which is statistically significant (P-value < 0.05). While none of different means within each group showed no statistically significant difference (by each measure and within each treatment, P-value > 0.05). Therefore, measured data within a group of treatments were the same means of detected CBN. When comparing average means among all treatments; detected CBN contents of treatment 2 (with diluted syrup in-hive fed and confined bees) was greater than treatment 1 (with diluted honey in-hive fed and confined bees) (Fig. 7). While average means of detected CBN between treatment 1 and treatment 2 as well as those between treatment 1 and controlled treatment 3 were not different. While detected CBN content in nominal terms (mg/kg) were much lesser than those of detected CBD content, and as in small amount as of detected THC content (Fig. 3, 5 and 7).

Table 8. Standard deviation on the measured data of detected CBN content dispersed to the sampling unit (each of 3 replicated beehives) mean.

Measure #	Treatment					
	1 (Diluted honey fed)		2 (Diluted sugar syrup fed)		3 (Controlled)	
	Means	Standard Deviation	Means	Standard Deviation	Means	Standard Deviation
CBN1	.6733	.5832	1.4133	.1629	1.5533	.3742
CBN2	.7833	.7006	1.6100	.5122	1.6833	.0058
CBN3	1.0000	0.0000	1.8133	.7055	1.3067	.3513

Table 9. Analysis of variance of detected Cannabinol (CBN) content.

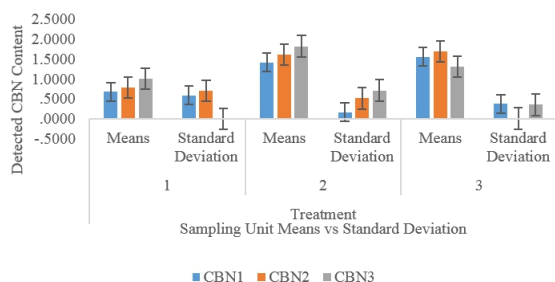| Sources of Variation	Sum of Squares	Degrees of Freedom	Root Means Square (RMF)	$F_{(7,8\&9)}$	P-value
Experimental Unit (Treatment)	3.368	2	1.684	6.290	0.034
Discrepancy	1.606	6	0.268		
Sum of between groups	4.974	8			
Time of Measure	0.141	2	0.070	0.392	0.684
Time of Measure * Exp. Unit	0.484	4	0.121	0.674	0.623
Discrepancy	2.156	12	0.180		
Sum of within group	2.781	18			
Sum Total	**7.755**	**26**			

Figure 6: Observation on the measured values of detected CBN content (CBN1-3 measuring time-points) related to the sampling unit (each of 3 replicated beehives) means.
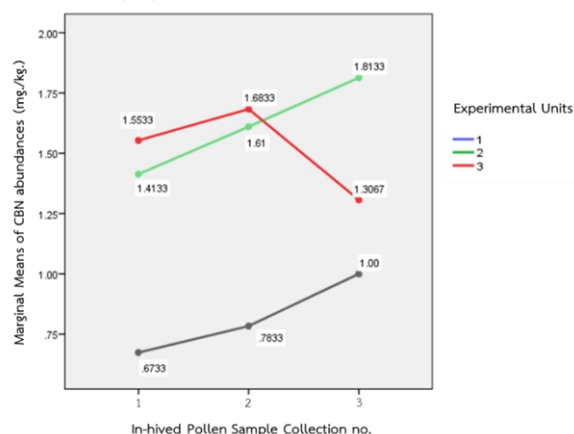

Figure 7: Means of detected Cannabinol (CBN) illustrated by treatment (experimental unit).

4. Conclusion, Discussion and Suggestion

In the conclusion, as the research results, there was a scientific proof that the unique compounds of Cannabinoids (CBD, THC and CBN), which are rich in *Cannabis sativa* L. (hemp plant), are transferred to bee products by means of raising *Apis mellifera* L. (honey bees) on the hemp plantation. This experimental results reiterated the theory of unique phytochemicals in plants, especially prolific flowers were transferred to and found in bee products [17], so called 'biological transformation'. The therapeutically bioactive potency of *Cannabis sativa* is apparent worldwide [18] since its content of unique cannabinoid constituents that are only found in cannabis plants also the demand of hemp products has been increasing, therefore, the industrial hemp plantations have been growing up [1] worldwide. Despite the fact that the decline of a number of bees in beekeeping industry in many countries are impacted from Colony Collapse Disorder (CCD) which is the unknown loss of bees. An expected cause is a floral resource scarcity during dearth period impacted from the climate changes and agricul-tural chemical uses etc. [6]. Therefore, mass flowering hemp crops can alternatively support honey bee population foraging [8, 9]. Since honey bees forage and collect hemp flower pollens as one of their individuals and colony's nutrients (protein), together with nectar (carbohydrate) discrete from plant flowers for their essentials to maintain colony healthy and propagation. This experiment was an alternative to cope with the impact. The hemp pollens were determined in the experiment rather than the plant resin, which one might recommend that there would be richer in cannabinoids contents. However, at this stage was designed as the prototype experiment, we needed to investigate which protocol is suitable choice to raise bees on hemp plantation in order to make them healthy and productive. Apart from the findings of the detection of CBD, THC and CBN in in-hive stored bee pollens, it also noted

that in the experimental methodology on different artificial supplements is separately fed to bees for investigation. We found that in the third treatment, even though bees are free foraging in opened hemp field, their choices of collecting other flower pollens are vastly, they also collect hemp pollens into hive as similar amounts as ones being confined in treatments with the netted hemp plantation. The foraging bees are preferable to collect massive hemp pollens for their food storages as the same findings as other researches [6, 8]. There was no sign on any negative impact to honey bees consuming Cannabinoids in all treatments during the experiment to support the previous study due to the lack of cannabinoid receptors in insects [10].

According to the findings, it would be useful in terms of business development in the future, especially for CBD which is high in *Cannabis sativa* L. (hemp), for example, CBD infused honey through the biological transformation. We suggest that this would be customized on demands for healthy food industry or even for Thai traditional and complementary medicine. Further research explorations in using bee raising protocol to produce bee products and long-terms impact to bees could be taken into consideration. Last, we would recommend to concerned authorities in considering the guidelines to control of *Cannabis sativa* L. strains with high contents of psychoactive THC and CBN potency to prevent any misconducting.

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The misuse of Tramadol among children and youth and the need for having efficient policy and laws enforcement

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Abstract

Tramadol, classified as a dangerous drug, is spreading among children and youth in many countries. This article aims to review and examine the misuse of Tramadol, the regulatory policies, and the gab of knowledge to be filled by conducting research. A literature review is employed to collect information. Based on the finding of researches and analysis, Tramadol is spreading in some African and West Asian countries. It is sold in general drug stores in Thailand on social media or in an internet café. Children and youth combine tramadol with a drink that has caffeine which is harmful to their physical and mental health. It is an urgent need to conduct the research and suggest the government to issue the efficient policy and law enforcement.

1. Introduction

Tramadol is a centrally acting analgesic with a multimode of action. It acts on serotonergic and noradrenergic nociception, while its metabolite O-desmethyl tramadol acts on the μ-opioid receptor. Its analgesic potency is claimed to be about one-tenth that of morphine. Tramadol is used to treat both acute and chronic pain of moderate to severe intensity. Tramadol monotherapy does not usually provide adequate analgesia. In chronic non-cancer pain, there is little evidence for the use of tramadol for more than three months.

Tramadol is considered to be a relatively safe analgesic. The main adverse reactions to tramadol therapy are nausea, dizziness, and vomiting, particularly at the start of the therapy. At therapeutic doses, tramadol does not cause clinically relevant respiratory depression. Tramadol is contraindicated, however, in patients with diminished respiratory function.

Tramadol is generally considered as a medicinal drug with a low potential for dependence relative to morphine. Nevertheless, tramadol dependence may occur when used for prolonged periods of time (more than several weeks to months). Dependence to tramadol may occur when used within the recommended dose range of tramadol but especially when used at supra-therapeutic doses. In many individuals with tramadol dependence, a substance abuse history is found.

Orally administered tramadol can produce opioid-like effects (both mentally and physically) but these effects are mild and not produced following parenteral administration. Tramadol is generally considered as a medicine with a low abuse potential relative to morphine, and this potential is associated with high dose oral tramadol. At supra-therapeutic doses and rarely at therapeutic doses, intoxications may occur.

Symptoms of tramadol intoxication are similar to those of other opioid analgesics but may include serotonergic and noradrenergic components. Symptoms include central nervous system (CNS) depression and coma, tachycardia, cardiovascular collapse, seizures, and respiratory depression up to a respiratory arrest. Fatal intoxications are rare and appear to be associated with large overdoses of tramadol and co-ingestion of other drugs (including alcohol).

Tramadol is used worldwide and is listed in many medical guidelines for pain treatment. It is mentioned as a step-2 analgesic in the WHO guidelines for cancer pain relief. Tramadol is also listed on several national essential medicines lists. It is, however, not listed on the WHO Model List of Essential Medicines (April 2013). There is growing evidence of abuse of tramadol in some African and West Asian countries considering large seizures of such preparations in North and West Africa. Abuse of tramadol is reported by Egypt, Gaza, Jordan, Lebanon, Libya, Mauritius, Saudi Arabia, and Togo. Because of the increasing rate of abuse, Egypt has up-scheduled tramadol in 2009.

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Tramadol is widely available via the Internet without a prescription. Websites provide many user reports on the non-medicinal use of tramadol. The legal status of tramadol differs internationally. In most countries, it is a prescription-only medicine. [1]

2.   The Spreading of Tramadol

The 2017 UNODC report indicates that Tramadol use was common among younger people and peaks in childhood before 15 years. There are about 35 million users of opioids globally. Although Cannabis remains the world's most widely used illicit drug (135 million users), opioids (such as morphine, heroin, methadone, buprenorphine, codeine, tramadol, oxycodone, and hydrocodone) are known to cause the greatest negative health impact. Global trends indicate an increased misuse of opioids with a 5% prevalence reported in Europe. [2]

Historically, tramadol has been considered to have limited abuse liability [3] Reasons for use of Tramadol include the need to relax, increase strength, and sleep. [4] In the study among university students, the predictor of the use of psychoactive substances includes gender (males 5 times more than females), living away from parents, parental marital status, and staying in a hostel. [5]

There is growing evidence of abuse of tramadol in some African and West Asian countries considering large seizures of such preparations in North and West Africa. Misuse of tramadol is reported by Egypt, Gaza, Jordan, Lebanon, Libya, Mauritius, Saudi Arabia, and Togo. Because of the increasing rate of abuse, Egypt has up-scheduled tramadol in 2009. In addition to the economic toll, the World Health Organization report that globally, the yearly mortality on account of an opioid overdose was between 70,000 and 100,000 deaths.[1] Besides, tramadol abuse has dramatically increased in the Middle East region, especially in Iran. The prevalence of lifetime tramadol misuse among Iranian adolescents was 4.8% (7.6% for males and 1.8% for females) [6]

An online survey of UK university students listed Tramadol as among the most commonly misused prescription drug. [7] This trend was noted also in many parts of Asia and Africa. A study in Egypt indicated that Tramadol is the most abused opioid. [8] Tramadol abuse has dramatically increased in Egypt since 2008 and has led to many admissions to addiction treatment centers [9]. A recent Lancet world report highlights the opioid crisis in Africa and its use for non-medical purposes. [10]

A case studied In Nigeria indicates the use of a Tramadol cross-sectional study among street children in Borno Northern Nigeria, reported a 7% prevalence of Tramadol misuse. [11] In Owerri, southeast Nigeria, a survey of the use of psychoactive substances amongst university students indicated that 53.4% admitted the use of Tramadol. [12]

According to the Tramadol Update Review Report of the World Health Organization in 2014, misuse of Tramadol has several health consequences and also associated with mortality. After frequent, prolonged tramadol use, many people develop a tolerance to the drug. This means they have to take larger doses to feel the drug's effects. Along with tolerance, tramadol users may experience withdrawal symptoms when they stop using the drug. Tramadol withdrawal can cause irritability, depression, and flu-like symptoms. People who abuse tramadol usually feel relaxed and happy. People with severe pain may also take higher doses of the drug, which puts them at higher risks of serious side effects. The risk of developing an addiction to tramadol is higher when the drug is taken with other substances, like alcohol, opioids, and sedative-hypnotics. Mixing these substances can lead to respiratory depression. It also increases the risk of seizure. [1]

3.   Generation Z and Risk to Drugs Addiction

Biologically, a child and youth is a human being between the stages of birth and puberty. The United Nations defines the youth is those persons between the ages of 15 and 24 years. [13] while the General Medical Council uses the term 'children' to refer to younger children who do not have the maturity and understanding to make important decisions for themselves. [14]

The children and youth term is replaced by the term generation Z in September 2000.[15] Generation Z refers to the generation that was born between 1996-2010. This generation has been raised on the internet and social media, with some the oldest finishing college by 2020 and entering the workforce.

Generation Z, is the youngest, most ethnically diverse, and the largest generation in American history, comprising 27% of the US population. The Pew Research recently defined gen Z as anyone born after 1997. Gen Z grew up with technology, the internet, and social media, which sometimes causes them to be stereotyped as tech-addicted, anti-social, or "social justice warriors." [16]

As global connectivity soars, generational shifts could come to play a more important role in setting behavior than socioeconomic differences do. According to a new Pew Research Center analysis of Bureau of Labor Statistics data, overall teens (ages 15 to 17) spend an hour a day, on average, doing homework during the school year, up from 44 minutes a day about a decade ago and 30 minutes in the mid-1990s. Teens are also getting more shut-eye than they did in the past. They are clocking an average of over nine and a half hours of sleep a night, an increase of 22 minutes compared with teens a decade ago and almost an hour

more than those in the mid-1990s. Sleep patterns fluctuate quite a bit – on weekends, teens average about 11 hours, while on weekdays they typically get just over nine hours a night. Teens now enjoy more than five and a half hours of leisure a day (5 hours, 44 minutes). The biggest chunk of teens' daily leisure time is spent on screens: 3 hours and 4 minutes on average. This figure, which can include time spent gaming, surfing the web, watching videos and watching TV, has held steady over the past decade. On weekends, screen time increases to almost four hours a day (3 hours, 53 minutes), and on weekdays teens are spending 2 hours and 44 minutes on screens. Time spent playing sports has held steady at around 45 minutes, as has the time teens spend in other types of leisure such as shopping for clothes, listening to music and reading for pleasure. Time spent by teens in other leisure activities has declined. Over the past decade, the time spent socializing – including attending parties, extracurricular, sporting or other entertainment events as well as spending time with others in person or on the phone – has dropped by 16 minutes, to 1 hour and 13 minutes a day. Teens also are spending less time on paid work during the school year than their predecessors: 26 minutes a day, on average, compared with 49 minutes about a decade ago and 57 minutes in the mid-1990s. Much of this decline reflects the fact that teens are less likely to work today than in the past. [17]

Larry D. Rosen (2010) studied "The influence of modern technology on the lifestyle of each generation in the United States of America" It was concluded that generation Z is the group that uses the most media per day. [18] which consistent with Grail Research (2010) found that the behavior of media exposure of Generation Z influenced by online media a lot have a passion for interactive media and social networks. [19]

The research on generation Z in Thailand which is conducted by Wendy Colleen Farrell and Tipnuch Phungsoonthorn [20], Wunderman Thompson Intelligence [21], and Stamina Asia [22] has similar findings that gen Z account for one-third of the Thai population access to information through increasingly ubiquitous Internet access. They use smartphones multiple times a day, 86% of gen Z Thais are comfortable buying products on their mobile phones, and 84% made payment through digital wallets.

There is a lot of research on youth and drugs. The most commonly used drugs are alcohol, tobacco, and marijuana. Recently, more young people have started vaping tobacco and marijuana. There is still a lot we don't know about the dangers of vaping. Some people have unexpectedly gotten very ill or have even died after vaping. There are many different reasons why a young person may take drugs, including they want to be accepted by friends or peers who are doing drugs, abused drugs can produce feelings of pleasure, some adolescents suffer from depression, social anxiety, stress-related disorders, and physical pain. Using drugs may be an attempt to lessen these feelings of distress, some young people may take stimulants for studying or anabolic steroids to improve their athletic performance. Young people are often motivated to seek new experiences, particularly those they perceive as thrilling or daring. [23]

Therefore, It would be concluded that the gen Z who was born and raised with technological advancements, can learn and access various information in which they are interested easily and quickly. Easy and convenient access to information can lead to a risk which would influence on the attitude and behavior of the gen Z because it may lead to misguidance or having strange values, then becoming inappropriate behavior due to characteristics of children and youth are in a period of curiosity and high-spirited behavior.

4. Tramadol Epidemic Among Children and Youth in Thailand

Tramadol or "Taxi" called by Thai teenagers according to the colors of the pill is spreading rapidly among children and youth in online communities, especially those who were born in 1995 or Generation Z because they were born with the advancement of communication technology and does not prioritize families because most were born during the time that Thai society began to have a lower birth rate. The households are a nuclear family which means that it consists of only parents and a child. Parents have to go out to work. They also have little attachment to grandparents or many other relatives causing a small development in feelings of attachment to the family. [24]

The Princess Mother National Institute on Drug Abuse Treatment (2016), revealed that There are 5 cases of tramadol addiction in 2014, 9 cases in 2015, and 46 cases in 2016, which are increasing every year. [25] The drug situation report in Bangkok area in 2017 and treads in 2018 of Office of the Narcotics Control Board is found that children and youths in Department of Youth Observation and Protection Bangkok in 2017 continue misuse of dangerous drugs such as Tramadol, Procodil, cough syrup, etc were 29.9%. [26] Statistical reporting on the abuse of dangerous drugs of children and young people in Thailand had not to include clear and widespread data collection. Because dangerous drugs are not a substance abuse group. There is little study about the effects of dangerous drugs and the abuse of dangerous drug behavior. Therefore, most people are not aware if children and young abuse of the dangerous drug.

In Thailand, Tramadol has a low price and can probably be found in general drug stores, on social media such as Facebook, Line, Instagram, Twitter, or in an internet caf?, etc. Therefore, the major problem that is being currently encountered in Thailand is that children and youth misuse of tramadol. The children and youth who tried these substances thought that these

are made of the unharmful mixture and can be bought at general drug stores without a thought that it is addictive or dangerous in any way. Except for tramadol, there are other 4 drugs in which children and youth misuse them:

1) Procodyl, a transparent brown liquid, can relieve allergies. When taken, it results in sleepiness.

2) Dextromethorphan, a tablet cough syrup, its effect results inactiveness but dizziness.

3) Dimetapp Elixir, a liquid-like, is an anti-allergic medicine and a decongestant, and 4) Alprazolam, a purplish pill, is used to treat anxiety like a narcotic which can help resist drowsiness, causing semiconscious stage, intoxication, euphoria, and fun.

According to the rules, procedures, and conditions for selling drugs of the Food and Drug Administration 2015, Tramadol must be sold in pharmacies that have a license by the authoritative pharmacists only. [27] But there are a lot of pharmacies without a license sale Tramadol illegally.

It can be concluded that the Thais children and youth are at risk of using drugs or Tramadol unless there is a serious concern to protect children and youth from the danger. There is a lot of research on prevention the youth and adolescent from drugs. Prevention starts with the family. A parent has a major impact on a child's decision not to use drugs. Prevention starts when a parent starts talking with and listening to the child, help the child make good choices and good friends. Drug use is much less likely to happen if a parent spends time with the child, talk with the child about the negative effects of alcohol and drugs would have on their brains and bodies and their ability to learn or play sports, correct any wrong beliefs of a child may have i.e. everybody drinks, marijuana won't hurt health, mixed Tramadol with some soft drink isn't dangerous. By using a mix of praise and criticism, parents can correct a child's behavior without saying a child is bad. Look for activities that the entire family can do together. Remind the child that real friends do not ask friends to do risky things like use alcohol, tobacco, or drugs. Reject friends when they don't want to do something that they know is wrong. This helps children build self-confidence and learn how to make healthy and safe choices. [28]

5. Regulatory Policies on Tramadol

There are regulatory policies on Tramadol in many countries. This article present regulatory policies based on the literature review of some countries as follow: Canada indicates Tramadol as Substance abuse and Schedule V drug. Hong Kong, New Zeeland, Singapore, Thailand, and the United Kingdom indicate as a prescription drug. Sweden indicates as Schedule I. South Africa indicates as Schedule V. USA indicates as Prescription, List of Drugs & Substances of Concern, and Schedule IV drug. (see Table 1.)

*Drug Scheduling [29]

Drugs, substances, and certain chemicals used to make drugs are classified into five (5) distinct categories or schedules depending upon the drug's acceptable medical use and the drug's abuse or dependency potential. The abuse rate is a determinate factor in the scheduling of the drug; for example, Schedule I drugs have a high potential for abuse and the potential to create severe psychological and/or physical dependence. As the drug schedule changes– Schedule II, Schedule III, etc., so does the abuse potential– Schedule V drugs represents the least potential for abuse. A Listing of drugs and their schedule are located at Controlled Substance Act (CSA) Scheduling or CSA Scheduling by Alphabetical Order. These lists describe the basic or parent chemical and do not necessarily describe the salts, isomers, and salts of isomers, esters, ethers and derivatives which may also be classified as controlled substances. These lists are intended as general references and are not comprehensive listings of all controlled substances.

Please note that a substance need not be listed as a controlled substance to be treated as a Schedule I substance for criminal prosecution. A controlled substance analog is a substance that is intended for human consumption and is structurally or pharmacologically substantially similar to or is represented as being similar to a Schedule I or Schedule II substance and is not an approved medication in the United States. (See 21 U.S.C. §802(32)(A) for the definition of a controlled substance analog and 21 U.S.C. §813 for the schedule.)

Schedule I

Schedule I drugs, substances, or chemicals are defined as drugs with no currently accepted medical use and a high potential for abuse. Some examples of Schedule I drugs are: heroin, lysergic acid diethylamide (LSD), marijuana (cannabis), 3, 4-methylenedioxymethamphetamine (ecstasy), methaqualone, and peyote

Schedule II

Schedule II drugs, substances, or chemicals are defined as drugs with a high potential for abuse, with use potentially leading to severe psychological or physical dependence. These drugs are also considered dangerous. Some examples of Schedule II drugs are: Combination products with less than 15 milligrams of hydrocodone per dosage unit (Vicodin), cocaine, methamphetamine, methadone, hydromorphone (Dilaudid), meperidine (Demerol), oxycodone (OxyContin), fentanyl, Dexedrine, Adderall, and Ritalin

Schedule III

Schedule III drugs, substances, or chemicals are defined as drugs with a moderate to low potential for physical and psychological dependence. Schedule III drugs abuse potential is less than Schedule I and Schedule II drugs but more than Schedule IV. Some examples of Schedule III drugs are: Products contain-

Table 1. Regulatory policies on Tramadol.

Regulatory Policies	Australia	Canada	Hong Kong	New Zealand	Sweden	Singapore	South Africa	Thailand	UK	USA
Substance abuse		✓								
Prescription			✓	✓		✓		✓	✓	
List of Drugs & Substances of Concern										✓
Schedule F		✓								
Schedule I					✓					
Schedule IV										✓
Schedule V	✓						✓			

ing less than 90 milligrams of codeine per dosage unit (Tylenol with codeine), ketamine, anabolic steroids, testosterone

Schedule IV

Schedule IV drugs, substances, or chemicals are defined as drugs with a low potential for abuse and low risk of dependence. Some examples of Schedule IV drugs are: Xanax, Soma, Darvon, Darvocet, Valium, Ativan, Talwin, Ambien, Tramadol

Schedule V

Schedule V drugs, substances, or chemicals are defined as drugs with lower potential for abuse than Schedule IV and consist of preparations containing limited quantities of certain narcotics. Schedule V drugs are generally used for antidiarrheal, antitussive, and analgesic purposes. Some examples of Schedule V drugs are: cough preparations with less than 200 milligrams of codeine or per 100 milliliters (Robitussin AC), Lomotil, Motofen, Lyrica, Parepectolin

It can be seen that the restriction on tramadol in foreign countries is different. Some countries have announced a schedule to control tramadol clearly include Sweden, United States of America, Australia, and the Republic of South Africa while, in New Zealand, tramadol is comparable to specially controlled drugs in Thailand and, according to the study, only Canada has changed the status of tramadol into a group of narcotics, announced in Canada Gazette since on 7 July 2007.

6. Conclusion

Children and youth in Thailand are considered to be vulnerable groups to the misuse of tramadol. Although the Food and Drug Administration (FDA) announced measures to control the distribution of tramadol, children and youth can easily buy it. If they continue misuse of tramadol, it will affect the physical health, mental health, and brain of children and youth in the long term.

The problem of tramadol misuse should be immediately and widely shared, such as providing knowledge to youth, explaining to the public about the situation of using drugs, the support from a happy family, the need

of regulations on the control of drug sales on the internet, the purchase from a clinic including an awareness of illegal activities by all sectors.

Protecting children and youth from the misuse of tramadol is a very important matter. Even though there is some research in Thailand on the tramadol problems, but there is a gap of knowledge on how to draw up the efficient policy as well as how to activate the law enforcement. Therefore, it is an urgent need to conduct research to tackle the misuse of tramadol.

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Genetic diversity of genus *Filopaludina* in the upper northeastern Mekong Basin of Thailand revealed by mitochondrial DNA sequences

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Abstract

This research was applied DNA barcoding tool for the molecular identification of genus *Filupaludina* in Mekong basin northeastern Thailand using mitochondrial-cytochrome c oxidase I (mt-COI). Ninety snails were collected from 9 locations along the river in four provinces (Loei, Nong Khai, Beung Kan, and Nakhon Phanom Provinces,). DNA extraction of individual snail was amplified using COI primers. The PCR products were selected and examined nucleotide sequence before being genetic analysis. The phylogeny analysis suggested that *Filupaludina* species showed monophyletic with disseminated clades and they were genetically similar to F. *martensi*. The haplotype diversity observed in *Filupaludina* species showed 10 patterns of distribution. The genetic distance within subspecies F. *martensi martensi* and *Filupaludina martensi cambodjensis* showed mean values equal to 0.1739 and 0.1203, respectively. In addition, the genetic distance within *Filupaludina sumatensi polygramma* showed 0.3431. Finally, unique haplotypes were commonly found in all locations. These findings revealed that the gene flow of *Filupaludina* between different locations is limited, leading to the genetic differences that were detected. This study is the first report of the genetic sequence of *Filupaludina martensi cambodjensis*, and *Filupaludina sumatensi polygramma* in the upper northeastern of Thailand.

Keywords: Genetic diversity, Viviparidae, COI gene

1. Introduction

The freshwater gastropod family Viviparidae Gray, 1847 is widely distributed in the world but absent from America and South America [1]. In Thailand Viviparidae were reported of all 8 genera are *Filopaludina, Trocotaia, Eyriesia, Idiopoma, Makongia, Sinotaia, Anulotaia* and *Cipangopaludina*. The pond snail *Filopaludina martensi* is previously knowing as *Siamopaludina*. This species is widely distributed and able to adapt to many habitats (lakes, ponds, canals, rivers and mountain streams with strong currents) often divided into many races and forms, more than 12 species, most of which are rassenkreis, one part synonyms, and the other part are subspecies spread in different region in Thailand, Laos, Cambodia, Myanmar, Malaysia, Indonesia along with Tonkin and south of china.[2]

Filopaludina sp. are well known as food for local people and also the only one genus that has been reported to the first or secondary snail intermediate hosts of parasite [2]. Three species (*F. martensi martensi, F. sumatrensis dorliaris* and *F. sumatrensis polygramm*) were reported to the parasitological importance of *Eechinostoma metacercaria* [3 – 5] which is the cause of Human echinostomiasis.[6] The four echinistome metacercaria, *Echinostoma malayanum, E. revolutum , E. ilocanum,* and *Hypoderaeum conoideum* have been reported for infecting human in Thailand[5] In these cause, the information of identifying the snail taxonomic status of hosts is important for health ecology and public health.

The taxonomy of viviparids is primarily based on shell morphology and the characters use only the shell shape, size, and sculpture. Whereas the color is limited use. By the reason of the pond snail is an animal with high shell variation.[8] In Addition too the generic names of viviparid snails *Vivipara, Viviparus, Bellamya,* and *Filopaludina* were called in the Philippines, Indonesia, Thailand and Malaysia, respectively. The genera and species of snail identifying are extremely confused in Southeast Asian countries.

2. Objectives

The objective of this study was to determine genetic diversity of *genus Filopaludina* in the Mekong basin of Thailand, based on molecular analysis.

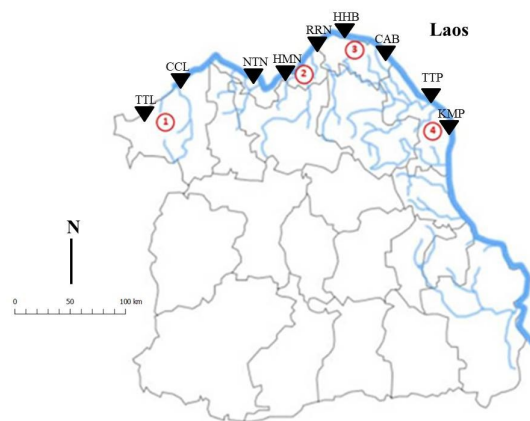*Corresponding author; email: ttbungorn@hotmail.com

Figure 1: Map showing the sampling sites in four provinces in Mekong basin of northeastern Thailand (1) Loei (2) Nong khai (3) Beung kan (4) Nakhon Phanom. Table 1 for detail.

Table 1. List of snail sample collection localities.

Code	Coordinates	District	Province	Habitat	Number
TTP	17°34'34.0284"N, 104°35'27.3372" E	Tha Utan	Nakhon Phanom	canal	10
CCL1	17°52'5.0016" N, 101°39'23.5512" E	Chaing Kan	Loei	Rice paddy	10
TTL	17°32'21.6564" N, 101°25'48" E	Thali	Loei	Rice paddy	10
NTN	17°50'31.3332" N, 102°35'4.2864" E	Thabor	Nong khai,	Pond	10
HMN	17°55'4.7064" N, 102°48'12.8556" E	Meuang Nongkhai	Nong khai,	Canals	10
RRN	18°13'44.7672" N, 103°10'30.792" E	Ratanawapee	Nong khai,	Swamp	10
PSN	18°2'46.1616"N, 102°18' 23.5656"E	Sang Kom	Nong khai,	pond	10
HHB	18°25'55.416" N, 103°26'12.9804" E	Horkam, Meang	Beung kan	Swamp	10
CAB	18°16'18.9156 " N, 103°50'11.7744 " E	Chaiyaporn, Meang	Beung kan	pond	10

3. Material and Methods

3.1 Populations sample

One hundred and fifty two were collected from 28 locations in the Mekong basin of northeastern Thailand (Loei, Nong Khai, Beung Kan and Nakhon Phanom Provinces) (Fig. 1) (Table 1). All living samples were anesthetized by immersing in clove oil solution (clove oil: water 55:500 ml) and cleaned with water. The individual foot tissue of snail was cut and frozen in -20 °C for further genetic analysis. The sample shells were washed with water, air dry and collected for external morphology for classification according to the method of Brandt R.A.M. (1974) [2 based on shell morphology and characteristics (size, height, shape, skin texture, shell color, stripe pattern on the ridge, ridge, composition of the operculum, operculum thickness and operculum color).

3.2 DNA amplification and sequencing

The genomic DNA was extracted from snail foot tissue using GF-1 tissue DNA extraction kit (Vivan-tis Technologies Sdn. Bhd, Malasia) according to the manufacturer's instruction with some modifications. The PCR amplification of mitochondrial gene was done with the set of primers cytochrome oxidase sub-unit I (COI) (5'GGTCAACAAATCATAAAGATATT GG-3') and performed in a final volume of 50 ml. The reaction mixture contained 10x buffer with 1nM M_gCl_2 10 μM of each primer, 1U of *Taq* DNA polymerase and 50 nM of DNA sample. The PCR protocol comprised of initial denaturation at 94 °C for 3 min, followed by 10 cycles of denaturation at 94 °C for 40 s, 50 °C for 45 min, 72 °C 30 min. followed by 36 cycles of annealing at 94 °C for 30 min 50 °C for 45 s, extension at 72 °C for 45 min and final extension at 72 °C for 5 min. The amplified products were checked using 1% agarose gel electrophoresis and sent for gel purification and sequencing by the Apical Scientific Sdn Bhd Company.

Table 2. Genetic distance calculated base on COI sequence comparing the 10 sample. The number of base substitutions between sequences are shown. Analyses were conducted using the Kimura 2-parameter model.

| | | F. m. muensis | | | | | F. m. cambodjensis | | | F.s. polygramma | |
		TTP1	HMN2	RRN2	TTL1	RRN3	CCL12	HHB1	CAB1	PSN2	NTN2
	TTP1										
	HMN2	0.06294									
F. m. muensis	RRN2	**0.01134**	0.06505								
	TTL1	0.32167	0.31587	0.34377							
	RRN3	0.11955	0.10119	0.12656	0.36216						
	CCL12	0.11584	0.10214	0.12934	0.348069	0.04479					
F. m. cambodjensis	HHB1	0.16391	0.16290	0.17237	0.361028	0.07906	0.09941				
	CAB1	0.14000	0.15312	0.13793	0.401702	0.16811	0.16492	0.22637			
F.s. polygramma	PSN2	0.15455	0.13586	0.15455	0.360771	0.14641	0.14416	0.19257	0.18402		
	NTN2	0.29372	0.29587	0.28801	**0.431801**	0.30476	0.29062	0.34319	0.31848	0.34313	

F. s polygramma *F. m martensi* *F. m cambodjensis*

Figure 2: Specimen of Pond snail subspecies of the genus *Filopaludina*.

4. DNA sequences analysis

The snail from 9 populations were selected 10 specimens for genetic study. The mitochondrial DNA sequences were alignment with BioEdit version 7.2.6 to comparison between freshwater gastropod DNA (550 bp COI gene) and Genbank DNA sequence. Phylogenetic analyses were conducted for the combined data set using inferred the Maximum-likelihood method. The evolutionary distances were computed using Kimura 2-parameter model were performed in MEGA-X.[6, 7]

5. Result and Discussion

The genetic distance from pair-wise comparison of COI sequence represents in (Table 5). Two species and ten sequences were comprised that provided. The value of genetic distance between subspecies among four *F.martensi martensi* is (0.01134-0.12656) among the F. *martensi cambodjensis* is (0.09941-0.40170) and among the F. *sumatrensis* is 0.34313. The Intraspecific variation shows highly different score. In the case of *F. martensi martensi* which collected from Nakorn Phamom and Nong Kai shown very closely relationship (0.01134). But the *F. martensi martensi* which collected from Leoi is diverging from other members (TTP, HMN and RRN) 0.32167, 0.31587 and 0.34377 respectively. Infer that Loei Province geography is highlands and high mountains scattered relate to high differentiation of same species. [12] While only two of *F. martensi cambodjensis* give a high genetic distance between HHB and CAB (0.226371) which collected from same province but HHB was closer with RRN (0.172369) than CAB1. Found that the unique haplotypes were commonly dependent on

different distance and locations with significant genetic differences between all populations. According to previous study genetic structure and geographical variation of *Bithynia siamensis goniomphalossensu lato* (Gastropoda: Bithyniidae) in the Lower Mekong basin revealed by mitochondrial DNA sequences and Phylogeny of freshwater viviparid snails in Japan by molecular phylogeny and taxonomy.[11, 13] These studies also show the population of *B.s. goniomphalosin* in the Lower Mekong in different catchments represented the gene flow between different collecting location. The highest genetic distance is 0.431801 of *F.sumatensis polygramma* and *F. martensi martensi* explain the extremely unique haplotypes. For the result of interspecific variation of three species show the minimum value is 0.01134-0.34313 and the maximum value is 0.34313 – 0.431801 confirm the snail variation is very high and rapidly variable on genetics.[13 – 15]

The phylogenetic tree is divided the monophyletic into six clades: clade A, clade B, clade C, clade D clade E and clade F. This study shows as clade A. The Taxa1 (RRN3, HHB1 and CCL12 sequences) was classified similarly to *F. martensi martensi* (MN997958- MN997960). They are similar of external morphology as well. It is possible to confuse in the genus name of viviparid snails in Southeast Asian countries and difficultly to use the key of external morphology to identify the snail in this family as mentioned above.[4] Whereas these snail might be invasive by human activities [16, 17] The clade E CAB1 was close with *F. sumatrensis* (MN997972, MN997978). Infer that CAB1 which was classified to specie *F. martensi* Beung kan, Thailand and *F. sumatrensis* might be immigrated by human[15]. The
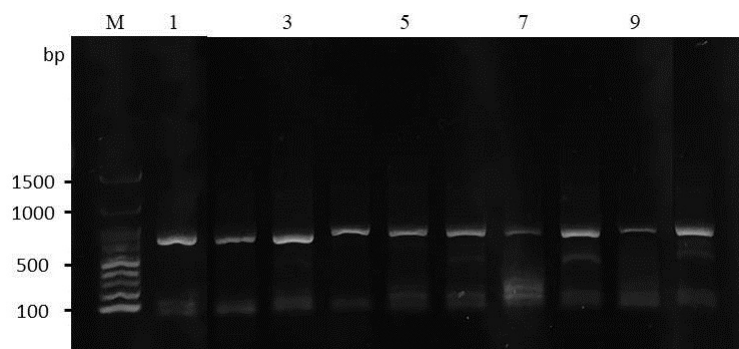
Figure 3: Gel electrophoresis of PCR products of snail using COI primer. Lane M = 100bp DNA ladder, lanes 1-9 = *Filopaludina* sp.
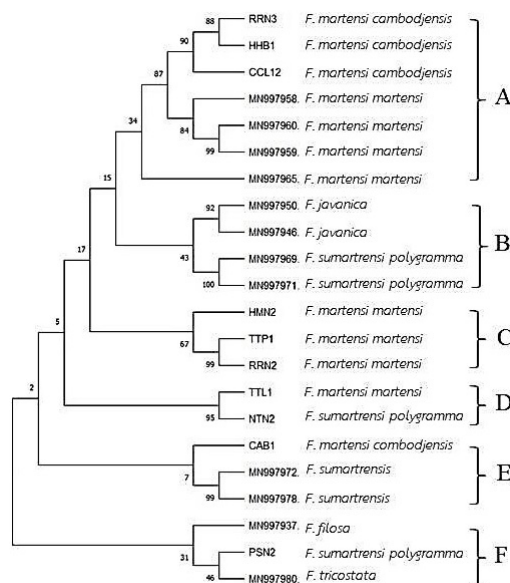

Figure 4: Phylogenetic tree of gastropod based on combined sequences from the COI genes. Each label represents a species/subspecies name followed by the specimen ID.GenBank; MN997937- MN997980.

clade F PSN1 was close with *F. filose* and *F. tricotata* (MN997937, MN997980) possibly that PSN1 which was classified to specie *F. sumatrensis polygramma* from Nong Kai was misclassified. And the specimen TTP1and RRN2 are very close relationship with 99% bootstrap replication

6. Conclusions

The PCR amplification and DNA sequencing were successful. The phylogenetic tree provided four clades and all samples of snail *Filopaludina* sp. from Mekong basin were the same clade. It can be said that the genetic diversity of *Filopaludina* sp. in Mekong basin of northeast Thailand is closer than other clades. This study is the first report of the genetic sequence of *Filupaludina martensi cambodjensis* and *Filupaludina sumatensi polygramma* in the upper northeastern Mekong basin of Thailand.

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On sensitivity of control chart for monitoring serially correlated data

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Abstract

The normality and independent observations were designed for double exponentially weighted moving average (DEWMA) and exponentially weighted moving average (EWMA) control charts. DEWMA control chart was modified from the EWMA control chart. The performance of the control chart is measured in terms of the average run length (ARL) that is the average number of samples before getting an out-of-control signal. In a real application, data are dependent and non-normal observations. The exponential distribution has application in any area of the subject such as reliability theory, survival analysis and queuing theory. The purpose of this paper was to study DEWMA and EWMA control charts using the first-order autoregressive (AR(1)), the first-order autoregressive moving average (ARMA(1,1)) and the first-order integrated moving average (IMA(1,1)) models for an exponential distributed process variable to study the efficiency of detecting small process mean shift. A simulation using the R program was applied to study the ARL performances for DEWMA and EWMA control charts for the small process mean shift. Tables of ARLs are presented for the various process mean shift. All ARL at various sets of parameters of the control chart calculation was completed based on 10,000 replications for a scenario. The EWMA control chart is more efficient than the DEWMA control chart in the detection of small process mean shifts as it dependably gives smaller ARL values and quickly detects the process shift at various levels of correlation and shifts in the process mean. The application of serially correlated data in the control chart literature has achieved with wide suitability. The design and application of the DEWMA and EWMA control charts suggest a model in the detection of small process mean shift by process control employees.

Keywords: EWMA, DEWMA, average run length, autocorrelated data, control chart

1. Introduction

The control chart is the most powerful tool for statistical process control to monitor and control a process. The control chart is a graphical expression of a quality characteristic that has been measured or computed from a sample versus the sample number or time [1]. The centerline (CL), the upper control limit (UCL) and the lower control limit (LCL) are shown on the control chart. The performance of the control chart is usually evaluated using average run lengths (ARLs) and standard deviations of run lengths (SDRLs). The traditional control charts designed for normally independent identically distributed (i.i.d.) observations but measurements from industrial processes are often serially correlated. Recently, many researchers have studied control chart for correlated data, Harris and Ross [2] investigated cumulative sum (CUSUM) and exponentially weighted moving average (EWMA) control charts based on time series model. Weib [3] presented the EWMA control chart to detect mean in-

creases in Poisson the first integer autoregressive processes. Suriyakat [4] studied the performance of the EWMA control chart to detect a small shift in the process mean with an exponential autoregressive integrated moving average process using explicit formula. The geometric moving average (GMV) control chart known as an EWMA control chart was introduced by Roberts [5], and also known to be effective for detecting small to moderate shifts in the parameters [6]. The double EWMA (DEWMA) control chart was extended from the EWMA control chart [7]. The EWMA and DEWMA control charts under Type-I censoring for gamma-distributed lifetimes were used for monitoring the mean level by using average run length, and it is found DEWMA control chart was an efficient chart for the detection of a shift in scale parameter [8]. Recently, Raza et al [9] introduced and compared the DEWMA and EWMA control charts under type?I censoring for Poisson?exponential distribution to monitor of mean level shifts using censored data, the performance of the DEWMA and EWMA control charts was evaluated using the average run length, expected quadratic loss, and performance com-

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parison index measures. Raza et al [10] presented conditional expected value (CEV) and conditional median (CM)?based DEWMA control charts for monitoring the type I censored data with Rayleigh distribution.

The DEWMA and EWMA control charts using a non-normal distribution with time series model are studied in the literature (see, e.g., [3, 4]). A time series is a set of observations , each one being recorded at a specific time [11] and may be used simply to provide a compact explanation of the data. The exponential distribution is a continuous random variable and has application in many areas of the subject such as reliability theory, survival analysis, queuing theory. The exponential distribution is also studied in the time series model. Several publications dealing with the subject of studying in the time series model using an exponential white noise have appeared in the literature (see, e.g., [12 – 15]). Therefore, the purpose of this paper was to study DEWMA and EWMA control charts using AR(1), ARMA(1,1) and IMA(1,1) models for an exponential distributed process variable to study the efficiency of detecting small process mean shift. The paper is organized as follows: Section 2 is devoted to the presentation of DEWMA and EWMA control charts. Section 3 describes the proposed AR(1), ARMA(1,1) and IMA(1,1) models for an exponential distribution. Section 4 both average run lengths (ARL's) and standard deviations of run lengths (SDRL's) are presented for the EWMA and DEWMA control charts, and in Section 5 are the concluding remarks.

2. Time Series Model with Exponential White Noise

Definition 1 A random variable X has an exponential distribution with parameter $\alpha > 0$ if its probability density function (pdf) is

$$f(x; \alpha) = \begin{cases} \alpha \exp(-x\alpha) & , x \geq 0 \\ 0 & , otherwise. \end{cases}$$

The mean, variance and cumulative distribution function (cdf) of exponential distribution are given in the following:

$$\begin{aligned} E(X) &= \frac{1}{\alpha}, \ V(X) = \frac{1}{\alpha^2}, \ F(x) = P(X \leq x) \\ &= 1 - \exp(-x\alpha); \ x \geq 0. \end{aligned}$$

Definition 2 The first-order autoregressive (AR(1)) process. Let $\{X_t\}$ is a stationary series satisfying the equations

$$X_t = \phi X_{t-1} + Y_t, \quad t = 0, \pm 1, \pm 2, \ldots$$

where $\{Y_t\}$ is an exponential distribution with parameter α, $|\phi| < 1$ and is uncorrelated with X_s for each $s < t$.

Definition 3 The autoregressive moving average processes. The time series $\{X_t\}$ is an ARMA(1,1) process if it is stationary and satisfies (for every t)

$$X_t - \phi X_{t-1} = Y_t + \theta Y_{t-1}, \quad t = 0, \pm 1, \pm 2, \ldots, \phi + \theta \neq 0.$$

Where $\{Y_t\}$ is an exponential distribution with a parameter α.

Definition 4 The integrated moving-average (IMA(1,1)) process. If $\{X_t\}$ is a nonstationary series satisfying the equations

$$X_t = X_{t-1} + Y_t + \theta Y_{t-1}, \quad t = 0, \pm 1, \pm 2, \ldots$$

where $\{Y_t\}$ is an exponential distribution with parameter α and $|\theta| < 1$.

3. The EWMA and DEWMA Control Chart for Monitoring the Process Mean

In this section, we propose to use EWMA and DEWMA to construct a control limit for serially correlated data under exponential white noise. We first consider the EWMA control chart proposed by Roberts [5]. The EWMA statistic is defined as

$$Y_t = (1 - \lambda) Y_{t-1} + \lambda X_t, \ t = 1, 2, 3, \ldots$$

where $\lambda \in (0, 1]$ is a constant and the starting value or the process target is $Y_0 = \alpha$. If the observations X_t are dependent random variables with variance σ^2, then the asymptotic of the variance of Y_t statistic for an AR(1) process is [16]

$$V(Y_t) = \sigma_X^2 \frac{\lambda}{2 - \lambda} \frac{1 + \phi(1 - \lambda)}{1 - \phi(1 - \lambda)}.$$

The control limits are given as follows:

$$\begin{aligned} UCL &= \alpha + E\sigma_Y = E \\ LCL &= \alpha - E\sigma_Y = 0 \end{aligned}$$

The DEWMA statistic is defined via the system of equation

$$Z_t = (1 - \lambda) Z_{t-1} + \lambda Y_t, \ t = 1, 2, 3, \ldots$$

where $\lambda \in (0, 1]$ is a constant and the starting value or the process target is $Z_0 = \alpha$. The asymptotic of the variance of Z_t the statistic is

$$V(Z_t) = \sigma_Y^2 \frac{\lambda \left(2 - 2\lambda + \lambda^2\right)}{(2 - \lambda)^3}$$

The control limits are given as follows:

$$\begin{aligned} UCL &= \alpha + D\sigma_Z = D \\ LCL &= \alpha - D\sigma_Z = 0 \end{aligned}$$

The average run length (ARL) is the way to define the performances of the EWMA and DEWMA control charts. The ARL is the average number of the

Table 1. Values of the UCL for the DEWMA and EWMA control charts with $ARL_0 = 300$.

λ	AR			ARMA			IMA		
	$\phi = 0.1$	$\phi = 0.5$	$\phi = 0.95$	$\phi = 0.1$ $\theta = 0.9$	$\phi = 0.5$ $\theta = 0.5$	$\phi = 0.95$ $\theta = 0.05$	$\theta = 0.1$	$\theta = 0.5$	$\theta = 0.95$
DEWMA									
0.05	1.252	1.502	21.420	0.133	0.379	20.360	236.103	197.006	14.062
0.1	1.425	2.555	22.802	0.177	1.285	21.662	253.828	141.672	15.047
0.2	1.728	3.045	24.067	0.327	1.560	22.880	263.008	146.633	15.571
0.3	2.019	3.471	24.710	0.561	1.829	23.520	265.914	148.323	15.782
EWMA									
0.05	1.400	2.590	22.516	0.343	1.344	21.400	253.000	141.000	15.000
0.1	1.779	3.014	23.760	0.581	1.624	22.513	262.000	146.000	15.540
0.2	2.271	3.635	24.750	1.058	2.104	23.540	266.500	148.480	15.920
0.3	2.722	4.123	25.258	1.534	2.550	24.000	268.000	249.410	16.220

Table 2. Performance for the EWMA and DEWMA control charts when $\phi = 0.1$, $\theta = 0.9$, $\lambda = 0.05$.

$\alpha + \delta$	AR(1)				ARMA(1,1)				IMA(1,1)			
	DEWMA D = 1.252		EWMA E = 1.400		DEWMA D = 0.133		EWMA E = 0.343		DEWMA D = 236.103		EWMA E = 253.000	
	ARL	SDRL	ARL	SDRL	ARL	SDRL	ARL	SDRL	ARL	SDRL	ARL	SDRL
1.00	300.5830	227.8410	299.2177	255.8091	300.2397	231.248	299.6991	282.1490	300.0160	15.6887	299.9737	16.4437
1.05	197.4920	130.663	**193.9646**	150.6475	**197.4080**	140.324	220.8649	205.2657	288.0712	15.4666	**286.7980**	16.2456
1.10	146.6900	84.8862	137.7283	99.2872	**142.9830**	87.1489	168.0187	153.5321	276.1806	14.7511	**274.5802**	15.8050
1.15	116.237	59.0084	105.3290	70.0818	**111.6680**	60.9768	133.1056	118.4791	266.2992	14.6848	**263.2337**	15.2829
1.20	95.2838	40.6877	**84.8635**	51.5819	91.8699	44.6205	107.1719	93.1459	256.4204	13.9437	**253.0287**	14.8260
1.40	62.4160	18.2616	**47.7030**	22.7658	56.3807	19.9168	55.0258	45.8441	225.3072	13.0659	**219.7015**	13.7684
1.60	49.1726	11.1799	**33.4061**	13.8455	42.6875	12.8323	34.5289	27.8799	201.6364	12.1787	**194.7259**	12.8720
1.80	41.8678	8.3621	**26.6598**	10.5440	34.6175	9.7276	24.5456	19.5876	183.6678	11.4827	**175.4715**	12.0420
2.00	37.1276	6.8787	**21.8290**	8.3762	29.5170	7.9448	18.0758	14.3802	169.2786	10.8164	**159.4881**	11.3877
2.50	29.6418	5.0958	**15.3927**	5.8292	21.9584	5.9232	11.1077	9.2792	142.6826	9.6664	**131.2124**	10.0904
3.00	25.1912	4.5102	**11.8922**	4.6197	17.6031	4.9212	7.7510	6.6089	125.1712	8.6722	**112.3858**	9.1932

Bold font represents the lowest ARL_1

sample points that are plotted before a point is beyond the control limits.

Definition 5 The stopping time

Let $\{Y_t, t = 1, 2, 3, \ldots\}$ be a sequence of random variables and $\tau = \min\{t : Y_t < LCL \text{ or } Y_t > UCL\}$ be the stopping time. Then, the ARL is defined to be the expected value of τ, $E(\tau)$.

4. Simulation Results

The performances of the EWMA and DEWMA control charts with serially correlated data are compared in this section. The upper limits are considered for these charts so that the simulation studies conducted here using R. In Table 1, the value of the upper limits for the DEWMA and EWMA control charts with the in-control (ARL_0) is 300. The upper limit of DEWMA control chart is smaller than the EWMA control chart for almost all models.

Algorithms are written in the R program [17] to compute the out-of-control $ARL(ARL_1)$, based on 10,000 repetitions for a shift of $\alpha(\alpha + \delta)$ and δ is shift size. The simulation procedure includes the following:

1. Pseudorandom numbers are generated by the R function.

2. The control statistic (DEWMA and EWMA) is calculated for all models.

3. The control statistic is compared with an experimental LCL and UCL (an experimental D or E is used)

and thus a run length is obtained and recorded.

4. After 10, 000 simulation runs, the 10,000 derived run-length values consist of a sample of the random variable run length, and the sample means and squared root of sample variance give the ARL and SDRL, respectively.

Tables 2-4 show the figures of simulation ARL given $ARL_0 = 300$, $\lambda = 0.05$ with different shift sizes: 0.00, 0.05, 0.1, 0.15, 0.20, 0.40, 0.60, 0.80, 1.00, 1.50, and 2.00. For all tables, the shift sizes increase, while the figures for ARL_1 decrease significantly, starting approximately at $ARL_0 = 300$. It is observed that the EWMA chart has the best performance for all models considered. When the mean increase simultaneously, the EWMA chart has a minimum ARL_1. However, when the mean increases from 1.05 – 1.20 based on $\phi = 0.1$, $\theta = 0.9$, $\lambda = 0.05$, the DEWMA chart has the best performance for the ARMA(1,1) model found in Table 2.

5. Conclusions and Discussion

The traditional control chart has been used extensively for process control, which is valid under the normal independence assumption of observations. In the real world applications, there are many types of dependent observations in which the traditional control chart cannot be used. The purpose of this paper was to study DEWMA and EWMA control charts using the first-order autoregressive (AR(1)), the first-order autore-

Table 3. Performance for the EWMA and DEWMA control charts when $\phi = 0.5$, $\theta = 0.5$, $\lambda = 0.05$.

	AR(1)				ARMA(1,1)				IMA(1,1)			
	DEWMA D = 2.250		EWMA E = 2.590		DEWMA D = 0.127		EWMA E = 1.344		DEWMA D = 131.313		EWMA E = 141.000	
$\alpha + \delta$	ARL	SDRL	ARL	SDRL	ARL	SDRL	ARL	SDRL	ARL	SDRL	ARL	SDRL
1.00	300.9760	227.0050	300.7160	252.8826	302.1567	232.7950	300.6725	255.2814	299.5039	15.7775	299.9304	16.2332
1.05	201.1068	131.6905	**194.1897**	148.3545	198.0802	129.3294	**194.2527**	157.2317	287.3571	15.1747	**286.7640**	16.0429
1.10	145.3392	81.6349	**137.6778**	97.6671	145.1894	83.6679	**138.1604**	98.9604	275.7411	14.8281	**274.4729**	15.6488
1.15	113.4026	54.9036	**105.0592**	67.4729	115.7281	58.8883	**106.0439**	70.6266	265.3977	14.6978	**263.2705**	15.4378
1.20	97.4464	42.5902	**84.4638**	51.0492	95.8502	41.8511	**84.4722**	51.6620	255.6588	14.1841	**253.1369**	14.7989
1.40	63.3718	18.2104	**48.0968**	22.5989	62.3689	18.2036	**47.9859**	22.7614	224.4891	13.1989	**219.5317**	13.8439
1.60	49.8326	10.7384	**34.1942**	14.1889	49.2161	11.3431	**33.8064**	14.1942	201.2044	12.3361	**194.0966**	12.7060
1.80	42.8038	8.4065	**26.8601**	10.0956	41.9737	8.4132	**26.5521**	10.5691	183.0617	11.3783	**174.5660**	12.0698
2.00	37.5182	6.8680	**22.3503**	8.1648	36.8899	6.9881	**21.8563**	8.3398	168.3457	10.8082	**159.2056**	11.4755
2.50	30.4138	5.2220	**15.9029**	5.6857	29.5159	5.2471	**15.3637**	5.9088	141.7723	9.5291	**130.7778**	10.1606
3.00	26.0872	4.3452	**12.5014**	4.4939	25.1534	4.4353	**11.9758**	4.7199	124.1507	8.7031	**111.9462**	9.2050

Bold font represents the lowest ARL_1

Table 4. Performance for the EWMA and DEWMA control charts when $\phi = 0.95$, $\theta = 0.05$, $\lambda = 0.05$.

	AR(1)				ARMA(1,1)				IMA(1,1)			
	DEWMA D = 21.420		EWMA E = 22.516		DEWMA D = 20.360		EWMA E = 21.400		DEWMA D = 14.062		EWMA E = 15.000	
$\alpha + \delta$	ARL	SDRL	ARL	SDRL	ARL	SDRL	ARL	SDRL	ARL	SDRL	ARL	SDRL
1.00	299.2810	207.9840	300.0697	227.7582	300.1024	207.8172	299.9306	227.4250	299.9992	16.4231	299.9274	17.2035
1.05	204.4376	118.2978	**196.0685**	130.5010	203.9524	116.6352	**196.5608**	128.8560	286.7340	16.0775	**285.6875**	16.9336
1.10	152.4874	71.5897	**143.8889**	82.0547	153.7275	72.3268	**145.1179**	82.9082	274.9691	15.7376	**272.8503**	16.6181
1.15	127.1698	50.3570	**114.3833**	57.3040	127.1637	49.8661	**114.5719**	57.9010	263.6656	15.3146	**260.7110**	15.8651
1.20	110.5070	35.1162	**96.2238**	42.1280	110.5389	35.2437	**95.5628**	41.1581	253.5760	15.0567	**249.9386**	15.8966
1.40	79.6826	15.1395	**61.9618**	17.7302	79.8274	14.8807	**62.0415**	17.7200	219.9641	13.9586	**214.2049**	14.6212
1.60	67.1816	9.9831	**48.9100**	11.2403	67.1949	10.0219	**49.0990**	11.1388	194.5663	12.8784	**187.5289**	13.6771
1.80	59.6928	7.8569	**41.8662**	8.5405	59.5166	7.9940	**41.8034**	8.3957	175.3479	12.1265	**166.6444**	12.9175
2.00	54.3138	6.8629	**36.8632**	6.8487	54.3507	6.9270	**36.9040**	7.0392	159.4014	11.4997	**149.9435**	12.3626
2.50	45.7408	5.3966	**29.5845**	5.2452	45.7956	5.4085	**29.4296**	5.3010	131.3488	10.1038	**120.2107**	11.0022
3.00	40.4782	4.6030	**25.1080**	4.4459	40.4065	4.6602	**25.0133**	4.4210	112.8009	9.2146	**100.0195**	9.8897

Bold font represents the lowest ARL_1

gressive moving average (ARMA(1,1)) and the first-order integrated moving average (IMA(1,1)) models for an exponential distributed process variable to study the efficiency of detecting small process mean shift. The EWMA control chart is more efficient than the DEWMA control chart in the detection of small process mean shifts as it dependably gives smaller ARL values and quickly detects the process shift at various levels of correlation and shifts in the process mean. Future research should be focused on other charts and the real-life situation data with exponential white noise as an alternative and should be applied to evaluate the ARL of all charts.

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