Research Article

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In-Service Training Using Integrated Smart Web Application for Statistical Analysis in Classroom Research

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Abstract

The purpose of this study was to improve teachers' knowledge of statistical methodologies for classroom research. In-service training was conducted utilizing our developed interactive web application, with five hundred forty-six volunteer secondary teachers from public schools. A questionnaire of statistical knowledge was used as a pre-test and post-test. A satisfaction form was used to assess participants' satisfaction with all components of the program. Descriptive statistics, the Chi-square test, Fisher's exact test, the Wilcoxon test, and the Kruskal-Wallis test were used to assess the responses, with the level of statistical significance set at 0.05. The results showed that, after participating in the program, the statistical analysis knowledge of the participants had increased significantly and met the pass criterion of more than 60% of the total score. It was also found that gender, school location and teaching level did not affect post-test performances. Satisfaction with the training documentation, lecturers, training format, and interactive web application was at the highest level. Gender, qualification level, and subject taught did not affect the satisfaction score for any of the four aspects. This study indicates that effective statistics learning can be achieved through guidance, training by experts and effective tools.

Keywords: *Statistics education research; Data analysis; Satisfaction; Interactive web application; In-service training*

1. Introduction

Education is a foundation of human development. For that reason, educational institutions must develop effective techniques of teaching and learning. The teacher is the driver of educational quality, leading the way in the development of national potential and competitiveness. Teacher development is essential to the success of the educational system on the global stage, particularly in the changing political, economic, societal, scientific, and technological world of the twenty-first century (Jamjuree, 2017).

Teachers have to conduct research in the classroom to assess issues that arise during the teaching and learning processes, and to develop potential solutions. The sharing of acquired research knowledge can lead to more effective teaching methods and strategies, and approaches to problem-solving that other teachers can use in their teaching and learning management (Smith & Sela, 2005; Aguilar-de Borja, 2018; James & Augustin, 2018).

To conduct research in the classroom, however, teachers need to have adequate knowledge and understanding of the various stages of research in the classroom. These stages include setting research objectives, developing research hypotheses, determining the scope of research, learning how to conduct research, analyzing data from research, and drawing conclusions based on research findings. Stewart (2013) demonstrated that a lack of knowledge at a certain level can lead to inaccurate findings, specifically when statistical knowledge in data analysis is required, and setting the conditions for utilizing statistics. Studies have shown that many teachers may lack the expertise and understanding to effectively conduct classroom research (Jantarakantee, 2012; Kunlasomboon et al., 2015; Ulla, 2018; Wahyuni, 2020). The use of statistical methods in the classroom was particularly problematic.

Teaching statistics to those who are unfamiliar with the subject can be challenging, and technology can provide useful aids. A large number of web-based teaching tool applets have been created and are freely available (Mills & Raju, 2011; Doi et al., 2016), but users must be aware of the exact statistical methodology involved, which entails several steps. Incorrect procedures can lead to unreliable results. In response to the need for guidance, we have developed an intensive short course for teachers who want to carry out classroom research. The course focuses on statistical analysis and is based on an interactive web application developed by one of our researchers (Chumnaul, 2022). The application enables teachers to produce reliable statistical data for classroom research and to produce statistical insights without having to manually analyze the data. This approach will eliminate analysis errors and make the results of classroom research more academically accurate, statistically sound, and reliable. This web application is also broad enough to be applied in all disciplines that make use of data analysis.

2. Literature Review

2.1 In-service teacher training

In-service teacher training is a method of improving the quality of instruction delivered by teachers. In-service teacher training programs are short education modules intended specifically for teachers who are already employed. These programs may include refresher courses, teaching workshops, or even institutional visits to help teachers acquire information that will help them provide better and more interesting lectures.

According to Abdul Rashid and Abdul Halim (2018), in today's ever-changing and globally competitive economy, teachers who produce innovative ideas and behaviors are critical to the success of educational institutions. A substantial body of research shows that teachers and the quality of their instruction are critical components of student learning. However, in low-resource settings teachers may lack knowledge, skills, or enthusiasm. Some impact evaluations (Popova et al., 2016) have revealed promising outcomes from actions aimed at improving teaching quality. Angrist and Lavy

(2001) used a matched-comparison design to estimate the effect of in-service teacher training on achievements in Jerusalem elementary schools. Differences-in-differences, regression, and matching estimates suggested that teacher training in secular schools led to an improvement in test scores. The estimates for religious schools were not clear-cut, perhaps because teacher training in the studied religious schools started later and was implemented on a smaller scale. Estimates for secular schools suggested that teacher training provided a cost-effective means of increasing test scores. The research of Harris and Sass (2006) indicated that teacher training generally had little influence on productivity, with the exception of a positive association between content-focused teacher development and productivity in middle and high school math. Kazmi et al. (2011) examined the effect of in-service teacher training on total quality management. The results showed that total quality management was better among teachers who had received in-service teacher training. No significant difference was found for variables such as teacher bias, the active learning environment, and class discipline.

Furthermore, Papanikolaou et al. (2017) found that a shortage of trained teachers was likely to be the major issue in the current unfavorable scenario, and the key to fixing this problem was to improve teacher training programs. The results of Junejo et al. (2017) showed that in-service training programs had a positive effect on teacher performance. The study also showed that teachers were enthusiastic about continuing their professional development. Jahangir et al. (2012) examined the effect of the Pakistan Higher Education Commission's sponsored in-service teacher training on the perception of good teachers among trainees. The results indicated a significant change in perceptions post-in-service training. These findings can be used to guide teacher education reform. According to Zimmerman (2000), a trained teacher is more successful and thus able to create better strategies to assist students in numerous aspects. This improvement in performance was due to the fact that various training programs, particularly in-service training programs, prepared teachers to be aware of certain functions, improve vision, and therefore become inclusive practitioners.

2.2 Classroom research

The use of classroom research by teachers raises a series of questions around the topics of professionalism, classroom practice, the social control of teachers and the usefulness of educational research. Each of these topics provides a rationale for teacher research. For example, classroom research by teachers can be justified by reference to professionalism because systematic self-study is a hallmark of occupations that are considered professions (Hopkins, 2008).

Classroom research, school-based research, teacher research, and action research are defined in the present study as any research undertaken and conducted by teachers in the classroom and/or in the school. This kind of research is done primarily to identify, examine, and understand a problem within the classroom or the school to which teacher-researchers want to find a solution (Burns & Kurtoglu-Hooton, 2014). Generally, teachers, as agents of knowledge and change, have to evaluate and assess the things they do inside the classroom in order to advance and enhance their teaching (Morales & Marie, 2016). McNiff (2010) outlined the benefits of action research for the professional development of teachers. Action research begins by reviewing whether teaching practice meets the desired and expected teaching outcomes. Secondly, it evaluates teaching pedagogies that have to be changed or improved. Lastly, it puts a value on the teacher's work and profession. Cain & Milovic (2010) suggested that action research can lead to desirable change, even when imported from elsewhere. Thus, action classroom research can answer the question of how to promote beneficial lifelong learning among education professionals. Furthermore, classroom research not only bridges the gap between theory and practice (Johnson, 2011), it also gives teachers professional skills in research, which is crucial for a transformative education (Hine & Lavery, 2014).

2.3 Statistics in education

Statistics can be used in different ways to help teachers. Descriptive statistics can identify trends in student performance through data visualizations, and different teaching methods can be compared by hypothesis testing, but teachers were found to experience difficulties understanding statistical inference concepts (Dolor and Noll, 2015). However, teachers who attended professional development workshops were found to be more likely to propose methods of improving mathematics and statistics teaching than those who did not (Umugiraneza et al., 2018).

Kim (2020) proposed that the emphasis of training should be on comprehending mathematical relationships and their application to statistical procedures. The researcher designed a pedagogical intervention consisting of a brief statistics training program centered on activity-based learning to improve the statistics teaching skills of pre-service secondary teachers and to address the learning challenges of students. The statistical knowledge required for teaching is not precisely equivalent to the knowledge required by a student of statistics. Teachers must be able to understand the subject matter and explain it to others. This dual demand on teachers necessitates the creation of sustainable teacher education programs (Leavy & Frischemeier, 2022). Watson and Smith (2022) believe that governments should adopt educational strategies to emphasize statistics not only as part of mathematics but across the curriculum. Statistics practice should be included in the approved school curriculum.

Chance et al. (2007) highlighted the importance of using technology in teaching statistics. There are numerous statistical software systems available to teachers. The most commonly used software systems are the Statistical Package for the Social Sciences (SPSS), Statistical Analysis System (SAS), R (open-source free software), Minitab, Stata, and MS Excel (developed by Microsoft) (Ali & Bhaskar, 2016). These programs are licensed (except R).

There are also a number of web resources related to statistical analyses such as https://www.socscistatistics.com/ (Social Science Statistics, n.d.), which offers three main sections: statistical calculators, which deal mainly with hypothesis testing; p-value calculators, which allow the users to derive p-values from Z, t, chi-square and Pearson (r); and descriptive statistics—averages, variance, a standard deviation calculator, and easy histogram and bar chart makers. Moreover, Welsch (2021) created https://statsomat.com/, a resource that can generate automated data analysis reports for applied researchers or data science learners who are unfamiliar with data analysis or programming. These apps handle classic statistical data analysis and machine learning questions in similar ways to a human analyst.

Yaşar et al. (2020) also developed a web-based application using the Shiny package in R software, which allows the evaluation of the results of scientific research to be made in a simpler, easier and more understandable way. This web tool will be updated on the updated R software packages. The developed interactive user-friendly web application is freely accessible through http://biostatapps.inonu.edu.tr/IAY.

3. Method

3.1 Participants

This study organized training for secondary school teachers from the provinces of Pattani, Yala, and Narathiwat on the southern border of Thailand. In these three border provinces, there are a total of 1,540 teachers at government secondary schools. The sample was acquired voluntarily from 546 applicants. However, some participants did not finish the entire course and did not submit comprehensive information. As a result, 423 participants took the pre-test, 366 participants took both the pre-test and the post-test, and 380 participants completed the satisfaction questionnaire.

3.2 Data collection

The training program we organized was entitled "Classroom research enhancement with an integrated smart research system for teacher development in the southern border provinces". Public relations and

applications were coordinated by the Secondary Educational Service Area Office of each province.

Due to the COVID-19 pandemic, training was conducted on an online platform. We explained the training program at the beginning of the session and then participants took the pre-test to assess their statistical background knowledge. The pre-test was a questionnaire of 30 shuffled statistical questions in a Google form. The training then began with a lecture on the fundamentals of data analysis, followed by the use of an interactive web tool to aid with data analysis. At the end of the training, the participants were required to complete the post-test, which was the same questionnaire as the pre-test. They were also required to complete a satisfaction form that would provide feedback on the training. This form was divided into four sections: the training documentation, the lecturers, the training format, and the interactive web application. The satisfaction score comprised 5 levels: strongly unsatisfied, unsatisfied, neutral, satisfied, and strongly satisfied. These levels were represented by numeric values 1 through 5 in the analysis.

Validity Before being utilized in training, all the questionnaires in this study were examined by three specialists and qualitatively validated using a content validity tool known as the Index of Item-Objective Congruence (IOC) (Oliveri et al., 2012). All the questions had an IOC value larger than 0.5, and were therefore deemed acceptable and could be applied to the 30-person tryout group. The difficulty level of each question was also assessed. The complexity of the questions was judged to meet the given requirements between 0.20 and 0.80.

Reliability Since the test questions passed the validity, difficulty, and stated criterion procedures, the reliability of all tests was investigated. Using the confidence value from Cronbach's alpha coefficient and the formula K-R 20 (Sriklaub et al., 2015), the coefficient of alpha was 0.82, which is regarded as valid. This value is only acceptable if it is greater than 0.70.

3.3 Data analysis

In this study, non-parametric statistics, including the Chi-square test, Fisher's exact test, the Wilcoxon test, and the Kruskal-Wallis test, were used for data analysis. The relationships between the qualitative variables presented in Table 1 were investigated with either the Chi-square test or Fisher's exact test. Because our data did not meet the normality assumption, the Wilcoxon and Kruskal-Wallis tests were used to find the median quantitative variable. All analyses in this study were performed using SPSS version 28, Microsoft Excel, and R statistical software version 4.2.1.

Table 1: A description of the qualitative variables used in the analysis

Qualitative variable	Variable Description	Coding
Post-test	Test score after participation in training	0 = No pass 1 = Pass
Gender	Teacher gender	0 = Female 1 = Male
Province	Province of the teacher's school	0 = Pattani 1 = Yala 2 = Narathiwat
Teaching level	Teaching level for which the teacher is accountable	0 = Junior high school 1 = High school
Subjects	Subjects for which the teacher is accountable	0 = Science 1 = Mathematics & Computing 2 = Foreign language 3 = Society & Religion 4 = Others
Qualification	Teacher qualification level	0 = Undergraduate degree 1 = Bachelor's degree 2 = Master's degree 3 = PhD

Qualitative variable	Variable Description	Coding
Satisfaction level	Level of satisfaction	1 = Strongly unsatisfied 2 = Unsatisfied 3 = Neutral 4 = Satisfied 5 = Strongly satisfied

To classify the average satisfaction score obtained from the satisfaction questionnaire, we utilized the following formula:

$$class\ interval = \frac{Maximum - Minimum}{Number\ of\ class\ interval} = \frac{5-1}{5} = 0.8$$

The levels of satisfaction corresponding to the various categories are presented in Table 2.

Table 2: The average score of each satisfaction level

Average score	Satisfaction level
4.21 - 5.00	Strongly satisfied
3.41 - 4.20	Satisfied
2.61 – 3.40	Neutral
1.81 – 2.60	Unsatisfied
1.00 – 1.80	Strongly unsatisfied

3.4 Smart data analysis interactive web application

The Smart Data Analysis Interactive Web Application is an interactive website that was developed using the Shiny package in R software. It can communicate and allow for interaction with users. Users first upload a data file in a .csv format from their computer to the website: *https://smart-data-analysis.shinyapps.io/for-educational-research/*. Then, the users provide necessary details for the data analysis of their research, such as the variables to be analyzed, the type of research hypothesis (two-tailed/one-tailed), the hypothesized value, and the confidence level. The information and details received on the website will be processed on the server hosted by RStudio, and then the server will automatically choose the appropriate statistical method for data input and send the analysis results back for display on the website screen (see Figure 1).

Figure 1: Smart Data Analysis Interactive Web Application flowchart (Chumnaul, 2022)

4. Results

4.1 Demographic data

According to the descriptive statistical analysis of the demographic data in Table 3, 291 females (79.5%) and 75 males (20.5%) took both the pre-test and the post-test. More participants (215, 58.7%) were from Yala Province than from Pattani (85, 23.2%) and Narathiwat (66, 18%) Provinces. The majority of the teachers (190, 51.9%) taught at the high school level. The others were junior high school teachers. According to the satisfaction questionnaire, the age of participants ranged from 23 to 59 years. Those aged 31 to 40 dominated the sample with 179 participants (47.1%). Teachers aged 51 to 60 had the lowest participation.

Table 3: Demographic information of the participants

Qualitative variable		*n*	Percentage
Gender	Female	291	79.50
	Male	75	20.50
Province	Pattani	85	23.20
	Yala	215	58.70
	Narathiwat	66	18.00
Teaching level	Junior high school	176	48.10
	High school	190	51.90
Age	≤ 30	70	18.42
	31 – 40	179	47.10
	41 – 50	82	21.58
	51 - 60	49	12.89

The median score on the pre-test was 10 out of 30, and the interquartile range (IQR) was 5. In the post-test, the median score more than doubled, to 22, representing 73.3% of the maximum score, and the IQR was 6.5 (Table 4).

Table 4: Summary statistics for pre-test and post-test scores

Quantitative variable	Minimum	Maximum	Mean (Sd)	Median (IQR)	Variance
Pre-test (*n* = 366)	4.00	26.00	10.75 (3.81)	10.00 (5.00)	14.51
Post-test (*n* = 423)	6.00	30.00	21.40 (4.60)	22.00 (6.50)	21.20

The majority of participants were strongly satisfied with their experience in each aspect. This level of satisfaction suggests that the participants were generally impressed with the course of training that we provided to them (Table 5).

Table 5: Summary statistics for satisfaction level

Descriptive statistics	Satisfaction score			
	Documentation for training	Lecturer	Format of training	Interactive web application
Mean	4.56	4.63	4.54	4.45
Median	4.75	4.88	4.75	4.67
Sd	0.53	0.48	0.54	0.63
IQR	0.75	0.65	1.00	1.00
Minimum	1.50	1.50	1.75	1.00
Maximum	5.00	5.00	5.00	5.00

4.2 Relationships between variables

4.2.1 Did the Participants Meet our Criterion after Training?

In designing this study, we determined that participants should be able to correctly answer more than 60% of the statistical questions in the post-test. In our analysis of the post-test scores, however, the data did not meet the assumption of normality. As a result, we decided to use a non-parametric statistic, the Wilcoxon signed-rank test, to determine whether the median of the post-test scores was greater than 60%. The obtained median of the post-test scores was statistically significant above 60% (p-value < 0.05), indicating that if teachers participated in our training, most of them would eventually meet our criterion.

4.2.2 Did Participants better Understand Statistical Analysis after Training?

One of the main objectives of this study was to improve statistical analysis skills to enhance the quality of classroom research projects. We assumed that participants would understand statistical analysis better following the training, regardless of how much knowledge they had before, what subject they taught, or where their school was located. We used a non-parametric statistic, the Wilcoxon matched-pairs signed-rank test, to see if the differences between the two tests were significant. The post-test scores were significantly higher than the pre-test scores (p-value < 0.05), showing that the teachers had greatly improved their grasp of statistical analysis.

4.2.3 Were there Differences in Post-Test Scores between Two Demographic Groups?

Gender and teaching level were two variables that could be divided into two categories, and we wanted to know whether the post-test scores differed between the two groups in these variables. The differences in post-test scores between male and female participants and between junior high school and high school teachers are shown below (Tables 6 and 7). The Wilcoxon signed-rank test was used for all of the tests listed below.

1. Testing classified by gender

When the data were broken down according to gender (Table 6), the median scores of both sets of results were identical. Furthermore, when we used the Wilcoxon signed-rank test, there was no statistical difference in the median scores between male and female teachers (p-value > 0.05). This result allowed us to conclude that gender did not affect individual learning in this particular course.

2. Testing classified by teaching level

The median scores of both groups of outcomes were very close to one another (Table 7). Using the Wilcoxon signed-rank test, we determined that there was no statistically significant difference in the median scores between junior high school teachers and high school teachers (p-value > 0.05). We concluded that the teaching level did not affect how teachers learned from this course.

Table 6: Wilcoxon signed-rank test classified by gender

Gender	*n*	Median	Range	w	*p*-value
Female	291	22	23	11364.00	0.580
Male	75	22	21		

Table 7: Wilcoxon signed-rank test classified by teaching level

Class	*n*	Median	Range	w	*p*-value
Junior high school	176	21	23	15119.00	0.113
High school	190	22	23		

4.2.4 Were there Differences in Post-Test Scores between Provinces?

The median scores of the three provinces were the same (Table 8). Moreover, using the Kruskal-Wallis rank sum test, we found that there was no statistically significant difference in the median scores of teachers from the three provinces (p-value > 0.05). We concluded that the location of the school where the teachers work did not influence the manner in which they absorbed the information presented in this course.

Table 8: Kruskal-Wallis rank sum test classified by province

Province	*n*	Median	Range	Kruskal-Wallis	*p*-value
Pattani	85	22	21	0.538	0.764
Yala	215	22	23		
Narathiwat	66	22	23		

4.2.5 Were there Relationships between Post-Test Status and Gender, Province, and Teaching Level?

It was made clear to participants from the start that the minimum score required to pass the exam was more than 60% and that a score of 60% or less would result in a "not pass" status. The vast majority of the participants achieved the required score (Table 9). On the other hand, we could not determine whether there was a relationship between this status and the qualitative variables of gender, province, and teaching level. Chi-square analysis was chosen to examine these relationships. As the p-value for each of the qualitative variables was greater than 0.05, it was clear that none of these variables had any effect on the post-test results.

Table 9: Chi-square analysis of the relationships between post-test status and gender, province, and teaching level

Variable		Status		Chi-square statistic	*p*-value
		Pass	Not pass		
Gender	Female	243	48	0.1985	0.6559
	Male	61	14		
Province	Pattani	68	17	1.2751	0.1592
	Yala	176	39		
	Narathiwat	60	6		
Teaching level	Junior high school	142	34	1.3629	0.2430
	High school	162	28		

4.3 Analysis of participant satisfaction

4.3.1 Were there Relationships between Satisfaction and Gender, Qualification Level, and Subject?

The majority of participants were strongly satisfied with their whole experience (Table 5). However, we wanted to investigate whether satisfaction levels were related to gender, qualification level, or subject taught. Fisher's exact test was used for this analysis, and the results are reported in Table 10. None of these variables had any relationship with the satisfaction level (p > 0.05), indicating that the majority of participants were strongly satisfied with the training in all aspects, regardless of gender, qualification level, or subject taught.

Table 10: Fisher's exact test was used to examine the relationships between satisfaction and gender, qualification level, and subject taught

Variable	Test statistics	Documentation for training	Lecturer	Format of training	Interactive web application
Gender	Fisher's exact test	4.650	5.459	3.003	4.874
	p-value	0.353	0.215	0.401	0.273
Qualification level	Fisher's exact test	18.021	26.350	14.640	18.853
	p-value	0.989	0.160	0.421	0.610
Subject	Fisher's exact test	17.910	14.111	12.947	13.650
	p-value	0.258	0.657	0.328	0.604

5. Discussion

5.1 Main results

This study was carried out in three different provinces in southern Thailand. The aim of the study was to enhance teachers' awareness of statistical procedures for the purpose of conducting classroom research. The training was conducted using our developed interactive web application which is a smart data analysis tool, designed especially for users who are not familiar with statistical analysis. A total of 546 secondary school teachers from public schools in the provinces of Yala, Pattani, and Narathiwat volunteered to take part in the event. A pre-test and a post-test were presented to participants. Both tests consisted of questions about statistical knowledge in a questionnaire format. A satisfaction questionnaire was also utilized to determine whether or not participants were satisfied with every aspect of the program. In order to evaluate the responses, descriptive statistics, the Chi-square test, Fisher's exact test, the Wilcoxon test, and the Kruskal-Wallis test were utilized, and the threshold of statistical significance was established at 0.05.

The findings demonstrated that after participating in the program, the participants' knowledge of statistical analysis was greatly enhanced, enabling them to meet our post-test pass requirement of more than 60% of the necessary knowledge. It was also found that the gender of the teacher, the province they taught in, and their teaching level had no bearing on their test performance after receiving the training. The highest level of satisfaction was reported in all four categories: training documentation, lecturers, training format, and interactive web application. None of the four factors that made up the satisfaction score were influenced by the teacher's gender, level of education, or the subjects they were responsible for teaching.

5.2 Limitations

It is crucial to note that there are limitations to this study. The first limitation is that the scope of the study was limited to three areas in southern Thailand, and only included teachers from public schools. Therefore, future studies should include teachers from both public and private schools. Secondly, all menus on the web application created for this training are provided in Thai because it was designed with Thai teachers in mind. As a result, only people who can read Thai will be able to use the app. Therefore, the web application should include English as an optional language to benefit more users. Thirdly, while the test questionnaire and satisfaction questionnaire required different information from participants, the satisfaction questionnaire was not designed to identify the person answering the questions. As a result, we were unable to conduct a simultaneous analysis of the two sets of data. Therefore, a broader range of information about the participants could be obtained in

the general information categories.

6. Conclusion

The goal of this study was to increase the understanding of statistical processes to help teachers conduct classroom research, particularly those who are unfamiliar with statistical analysis. The training was completed with the help of our developed interactive web application, which is a smart data analysis tool. Regardless of gender, province, or teaching level, teachers showed considerably improved knowledge of statistical analysis after participating in the program. Overall levels of satisfaction were high in all areas.

Despite the fact that all the participating teachers were fully trained, their knowledge of statistics was insufficient to correctly complete classroom research procedures. More training in skills and knowledge is required for teachers, not just in statistics, but in a variety of other areas as well, in order to improve their capacity to teach. As a result, students will learn more effectively, and the education system as a whole will benefit.

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