



Research Article

DEVELOPMENT AND EFFICIENCY OF DATA STRUCTURES AND ALGORITHMS TEACHING DOCUMENT

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ABSTRACT

The objectives of this research were to (1) develop and find the efficiency of the Data Structures and Algorithms teaching document (5652201) Bachelor of Science Program, Management of Information Technology, Faculty of Industrial Technology, Phranakhon Rajabhat University according to the efficiency of 80/80 criteria, (2) to find the Efficiency Index of the Data Structures and Algorithms teaching document, (3) to compare the learning achievement of the Data Structures and Algorithms before and after using the teaching document and (4) to study students' satisfaction towards the Data Structures and Algorithms teaching document. The samples of this research were 12 students of the Management of Information Technology Program of the second semester in academic year 2021. The samples were selected by using the Purposive Sampling. The research instruments were the evaluation form of the teaching document, pre-test/post-test, and students' satisfaction questionnaire. The results were found that the efficiency of the teaching document (E1/E2) had been 80.58/81.92. The effectiveness index was equal to 0.71 which means the students' learning progress increased by 71 percent after teaching by using the Data Structures and Algorithms teaching document (5652201). It was also found that the learning achievement after was higher than before learning at the statistically significance level of 0.05.

Keywords: Efficiency of Teaching Document, Learning Achievement, Effectiveness Index

INTRODUCTION

Ministry of Education Strategic Plan requires the development of management of learning quality development, increasing the standard and raising the country's competitiveness. Together with the strategic goals of the Information and Communication Technology (ICT) Policy Framework of Thailand (B.E. 2011–2021) (IT2020) also focus on developing the information infrastructure and future communication to strengthen the economy and develop human capital in information technology and communication for the year B.E. 2021. It also includes ICT industry development, government services, and equality strategy of social and ICT for environmental sustainability. Moreover, in the same way, Phranakhon Rajabhat University's strategy emphasizes the development of leadership that is aware of changes, creates jobs, and generates income with professional ethics. It also includes language skills development, communication skills, and ethical and creative use of information and information technology. Ministry of Digital Economy and Society (2021)

The Bachelor of Science in Management of Information Technology Program is one of the 4-year undergraduate courses/ curriculums within the Faculty of Industrial Technology. This curriculum was approved to open for teaching by the Office of the Higher Education Commission in B.E. 2549 and has been revised every 4 years – the current one is a revised curriculum in B.E. 2019. The total number of credits throughout the curriculum is not less than 130 credits, including General Education 30 Credits, Specific Courses 94 Credits, and Electives 6 Credits. In particular, the subject of Data Structures and Algorithms (5652201) is contained in the specific course, a compulsory subject that all first-year students of Management of Information Technology Program must register for in the second semester of every academic year. As a teacher of Data Structures & Algorithms, the researcher has developed a teaching document or documentation, which the teacher must develop himself using his knowledge, skills, and provide materials for teaching and learning in accordance with the National Education Act, No. 4 (B.E. 2019) and Undergraduate Program Standard Criteria (B.E. 2015). Therefore, the content and knowledge that are suitable for learners were gathered and compiled into the teaching document of this subject in accordance with the specified curriculum structure. Also, the research results will benefit in solving problems and making teaching and learning more effective. Consequently, in order to have a standardized teaching document through research and experimental process, the researcher, as a teacher, therefore, developed the teaching document for Data Structures and Algorithms which was used with the students of the Management of Information Technology Program in semester 2/2021 academic year in order to study the efficiency of the said document.

Due to its complexity, the score report or learning achievement of Data and Algorithms (5652201) in the previous semesters after the assessment divided students into three groups: low

achiever, average achiever, and high achiever. Specifically, the group of low achievers would lack enthusiasm when they thought that they would not be able to catch up with other groups of students. As a result, this affected their passing scores, which were lower than the criteria of 60 percent. According to the research result of Thongkaeo (2563), the solution to this problem was to develop the teaching document and create teaching activities to help increase the learning achievement in this course.

OBJECTIVES OF THE RESEARCH

1. To develop and find the efficiency of the Data Structures and Algorithms teaching document according to the efficiency of 80/80 criteria
2. To find the Effectiveness Index of Data Structures and Algorithms teaching document of Bachelor of Science (B.Sc.) in Management of Information Technology, Faculty of Industrial Technology
3. To compare the learning achievement of Data Structures and Algorithms before and after using the teaching document
4. To study the students' satisfaction with the Data Structures and Algorithms teaching document.

BENEFITS OF THE RESEARCH

1. Information Technology Program, Faculty of Industrial Technology will have a quality teaching document for teaching and learning Data Structures and Algorithms in order to apply it to relevant teachers and students.
2. The developed teaching document can be used as a model for other courses or subjects.
3. The results of this research will be beneficial for guidelines of teaching development and developing quality undergraduates according to the standards of the Office of the Higher Education Commission (OHEC) / Ministry of Higher Education, Science, Research and Innovation (MHESRI)

SCOPE OF STUDY

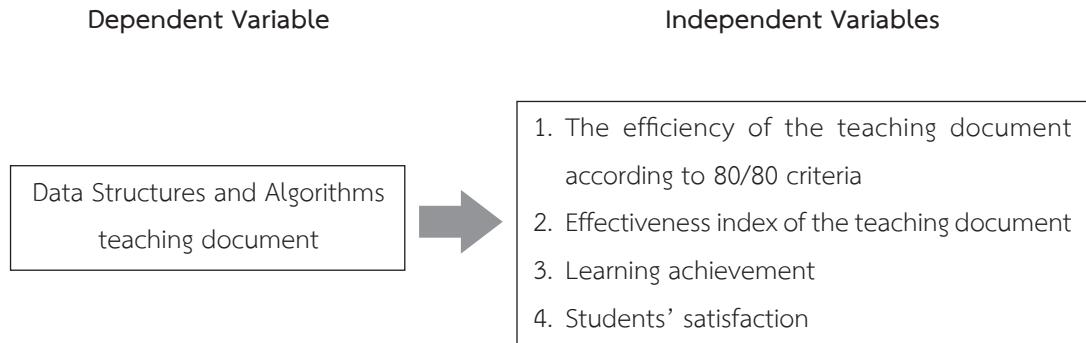
1. The research population was 12 undergraduate students of the Management of Information Technology Program who studied Data Structures and Algorithms in the semester 2/2021 academic year.

2. The content used in this research was about Data Structures & Algorithms, Bachelor of Science, Management of Information Technology Program, Faculty of Industrial Technology, Phranakhon Rajabhat University.
3. This research was implemented in the semester 2/2021 academic year.

HYPOTHESES

1. The efficiency of the teaching document was equal to or higher than the efficiency of the 80/80 criteria (Thongkaeo, 2021).
2. The Effectiveness Index of the teaching document was higher than 0.60 (Thongkaeo, 2021).
3. The learning achievement after teaching using the teaching document was higher than before.
4. The students were satisfied with the teaching using the teaching document with an average score above 3.0 (Thongkaeo, 2021).

HYPOTHESES



Picture 1 Research Framework

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HYPOTHESES

Population and Samples

The research population was 12 undergraduate students of the Management from Information Technology Program who studied Data Structures and Algorithms in the semester 2/2021 academic year.

Research Instruments

The research instruments were the evaluation form of the teaching document, pre-test/post-test, and students' satisfaction questionnaire regarding the content, exercises, quizzes, and learning activities of the teaching document.

Data Collection

The data were collected by using the created research instruments every week, 15 weeks in total.

Data Analysis

This was an Experimental Research. The data were collected from 12 students of the Management of Information Technology Program (Regular Class) who studied Data Structures and Algorithms in the semester 2/2021 academic year. The data were analyzed by using a t-test with IBM SPSS software to find the efficiency of the teaching document, effectiveness index, learning achievement, and students' satisfaction with the teaching document.

RESEARCH RESULTS

The objectives of this research were to develop the Data Structures and Algorithms teaching document and find the Effectiveness Index of the Data Structures and Algorithms teaching document, compare the learning achievement, and study students' satisfaction with the teaching document. The data were analyzed and reported as the following items:

1. Results of Quality Analysis of the Teaching Document
2. Results of Efficiency of the Teaching Document
3. Results of Effectiveness Index of the Teaching Document
4. Comparative results of the Learning Achievement before and after Teaching by Using the Teaching Document
5. Evaluation results of Students' Satisfaction with the Teaching Document

1. Results of Quality Analysis of the Teaching Document

The results of the quality analysis of the Data Structures and Algorithms teaching document (5652201) of the Bachelor of Science, Management of Information Technology Program, Phranakhon Rajabhat University were divided into 5 aspects, which consisted of Behavioral Objectives, Course Content, Teaching, and Learning Activities, Practice Test, and Achievement Test. These research instruments were analyzed by using Item-Objective Congruence (IOC). The results were as follows:

Table 1 Results of Quality Analysis of the Data Structures and Algorithms Teaching Document

No.	Aspect	\bar{X}	S.D.	Interpreting
1.	Behavioral Objectives	4.50	0.49	high
2.	Course Content	4.53	0.52	highest
3.	Teaching and Learning Activities	4.54	0.51	highest
4.	Practice Test	4.61	0.45	highest
5.	Achievement Test	4.50	0.45	high
Average		4.54	0.48	highest

From Table 1 Result of Quality Assessment of the Data Structures and Algorithms Teaching Document (5652201) of Bachelor of Science, Management of Information Technology Program, Phranakhon Rajabhat University by 5 specialists for those 5 aspects mentioned above, the results were found that: the overall aspect was at a high level (average = 4.54). For each aspect, it was found that: The aspect of the Practice Test was at the highest level (average = 4.61). Respectively, the aspect of Teaching and Learning Activities was at a high level (average = 4.54).

2. Results of Efficiency of the Teaching Document

Results of Efficiency of the Teaching Document by using the efficiency of 80/80 criteria

80 (E1) = The average score of all students taking the practice tests (percentage)

80 (E2) = The average score of all students taking the achievement tests (percentage)

After using the teaching document to try out with the samples, the efficiency of the teaching document was analyzed as the following table:

Table 2 Results of Efficiency of the Teaching Document

Scores	N	Σx	\bar{X}	Percentage
Scores of Practice Test	12	967	80.58	80.58
Scores of Achievement Test	12	983	81.92	81.92

Table 2 shows that after taking the Data Structures and Algorithms teaching document (5652201) of the Bachelor of Science in Management of Information Technology Program, Phranakhon Rajabhat University with 12 samples, the practice tests were passed at 80.58 percent of the total score of all the questions which was higher than the 80 percent criteria (E1). The samples also show that the achievement tests were passed correctly at 81.92 percent which was higher than the 80 percent criteria (E2). Therefore, it means that teaching and learning using the teaching document was effective due to efficiency exceeding the 80/80 criteria.

3. Results of Effectiveness Index of the Teaching Document

The result of the Effectiveness Index of the Data Structures and Algorithms teaching document (5652201) of the Bachelor of Science in Management of Information Technology Program, Phranakhon Rajabhat University by using the Comparison of Control Group of Effectiveness Index (Kitrakarn, (1999: 1-2) was 0.71 or percentage of 71 as shown in the following table:

Table 3 Scores of Pre-test and Post-test

Student	Scores		Score Differences	
	Pre-test (X_1)	Post-test (X_2)	$D = X_2 - X_1$	D_2
1	33	80	47	2209
2	29	83	54	2916
3	20	81	61	3721
4	50	83	33	1089
5	44	82	38	1444
6	36	81	45	2025
7	47	83	36	1296
8	27	82	55	3025
9	33	83	50	2500
10	65	81	16	256
11	46	82	36	1296
12	32	82	50	2500
Total	$\Sigma X_1 = 462$	$\Sigma X_2 = 983$	$\Sigma D = 521$	$\Sigma D^2 = 24,277$
Average	$\bar{X}_1 = 38.50$	$\bar{X}_2 = 81.92$		

The analysis of the Effectiveness Index of the Data Structures and Algorithms teaching document (5652201) of the Bachelor of Science in Management of Information Technology Program, Phranakhon Rajabhat University, by using the Comparison of Control Group of Effectiveness Index (Kitrakarn, 1999:1–2), the Effectiveness Index (E.I.) formulation was as follows:

$$\begin{aligned}
 E.I. &= \frac{81.92 - 38.50}{100 - 38.50} \\
 &= 0.71
 \end{aligned}$$

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4. Comparison of Results of Learning Achievement before and after Teaching by Using the Teaching Document

The data of pre-test and post-test of the samples in each lesson's results were analyzed by using Paired - Sample t-test. It was found that t -test = -12.254, Sig. (2-tailed) = .000 which was lower than the statistical significance level of 0.05. It showed that the pre-test scores were correlated with the post-test scores. Also, after teaching by using the Data Structures and Algorithms teaching document, the post-test scores were increased at the statistical significance level of 0.05, or 95% confidence level, with a minimum difference = -51.215 and maximum difference = -35.619. It means that the results of the comparison of the pre-test and post-test were different in Table 4.

Table 4 Pre-test and Post-test Scores

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	pre	38.50	12	12.310	3.554
	post	81.92	12	.996	.288

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	pre & post	12	.078	.810

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)			
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference							
				Lower	Upper						
Pair 1	pre - post	-43.417	12.273	3.543	-51.215	-35.619	-12.254	.000			

5. Evaluation Results of Students' Satisfaction with the Teaching Document

The evaluation results of students' satisfaction with the Data Structures and Algorithms teaching document (5652201) of the Bachelor of Science in Management of Information Technology Program, Phranakhon Rajabhat University, were as follows:

Table 4 Mean and Standard Deviation of Students' Satisfaction towards the Teaching Document

No.	Questions	$n = 12$		Interpretation
		\bar{X}	S.D.	
1	Clarity of learning objectives in the teaching document	4.50	0.67	high
2	Learning objectives covered the course content	4.50	0.52	high
3	Content presentation was in a clear sequence	4.58	0.51	highest
4	Course content covered the learning objectives	4.50	0.52	high
5	Easy to understand the content	4.75	0.45	highest
6	Fonts were clear and easy to read	4.67	0.49	highest
7	Using clear illustration and easy-to-understand	4.42	0.79	high
8	Suitability of the activities to the specified time/duration of time	4.58	0.51	highest
9	Appropriate amount of content for each unit	4.33	0.65	high
10	Clear instructions of practice and achievement tests	4.75	0.45	highest
11	Clear measurement and evaluation	4.50	0.80	high
12	Duration of study in each topic was appropriate	4.50	0.67	high
13	Students learned according to the objectives	4.50	0.52	high
Average		4.54	0.58	highest

From table 4, the students' satisfaction with the Data Structures and Algorithms teaching document (5652201) of the Bachelor of Science in Management of Information Technology Program, Phranakhon Rajabhat University, it was found that the overall aspect was at the highest level ($\bar{X} = 4.54$). For each aspect, it was found that Aspect of Easy-to-Understand Content was at the highest level ($\bar{X} = 4.75$). Aspect of Clear Instructions of Practice and Achievement Tests was also at the highest level ($\bar{X} = 4.75$). On the contrary, Aspect for Using Clear Illustrations and Easy-to-Understand were at a lower level ($\bar{X} = 4.42$). Also, Aspect of Appropriate Amount of Content for Each Unit was at the lowest level ($\bar{X} = 4.33$).

RESEARCH CONCLUSION AND DISCUSSION

Research Conclusion

The research result according to objective (1): to develop and find the efficiency (80/80 Criteria) of the Data Structures and Algorithms teaching document (5652201), Bachelor of Science, Management of Information Technology, Faculty of Industrial Technology, Phranakhon Rajabhat University, was found that the efficiency index of the teaching document (E1/ E2) was 80.58/81.92. The result according to objective (2): to find the efficiency index of Data Structures and Algorithms teaching documents. It was found that the effectiveness index was equal to 0.71, which means the students can increase their learning progress by using the teaching document by 71 percent.

The result, according to objective (3): to compare the learning achievement of the Data Structures and Algorithms before and after using the teaching documents. It was found that the post-test scores were higher than the pre-test scores at the statistical significance level of 0.05. The results according to objective (4): to study students' satisfaction with Data Structures and Algorithm teaching documents, it was found that the overall aspect was at the highest level ($\bar{X} = 4.51$). For each aspect, it was found that Aspect of Easy-to-Understand Content was at the highest level ($\bar{X} = 4.75$). Aspect of Clear Instructions of Practice and Achievement Tests was also at the highest level ($\bar{X} = 4.75$). In contrast, Aspects of Using Clear Illustration and Easy-to-Understand and Aspect of Appropriate Amount of Content for Each Unit were at the lowest level, ($\bar{X} = 4.42$) and ($\bar{X} = 4.33$) respectively. As an emphasis, the overall aspect of students' satisfaction was at the highest level ($\bar{X} = 4.54$), higher than the criteria: 3.

Research Discussion

The research discussions of the research on Development and Efficiency of Data Structures and Algorithms Teaching Document (5652201) were as follows: Firstly, the result of the efficiency and effectiveness index of Data Structures and Algorithms teaching document (5652201) of the Bachelor of Science in Management of Information Technology Program was 80.58/81.92, which was higher than the efficiency of 80/80 criteria. This was because the students actively paid attention to the study. They were also required to take a pre-test before beginning the lessons. This research result was consistent with research on The Development of Industrial Design Course's Teaching Material for Industrial Technology Faculty Students of Kamphaeng Phet Rajabhat University (Promsaijai, 2019), in which the research results were as follows: Every chapter of the industrial design course's teaching material was efficient with an Effectiveness Index: E1 = 84.08 and E2 = 82.50. Also, the students' learning achievements after using the material were higher than before at a statistical significance level of 0.05. The average pre-test score was 13.80 and the average post-test score was 30.09. This was consistent with the result of the Effectiveness Index of Data Structures and Algorithms teaching

document of the Bachelor of Science in Management of Information Technology Program which the Effectiveness Index was 0.71 –which means that the students increased their learning progress at a percentage of 71 which was higher than the criteria of 0.60. The result was also consistent with research on Construction and Efficiency Evaluation of the Instructional Material on Marketing Service Subject Upthong (2018). with the Effectiveness Index of 0.8946. It means that the students increased their learning progress at a percentage of 89.46. The result was also consistent with research on The Development and Efficiency of Instructional Package on Object Detection by Cooperative Learning Management using the Jigsaw Technique (Toontham and Toontham, 2016), where the Effectiveness Index was 77.36 – higher than the criteria of 70.

Secondly, the result of learning achievement before and after teaching by using the Data Structures and Algorithms teaching document was found to be that the post-test scores were higher than pre-test scores at a statistical significance level of .05. It indicates that teaching and learning by using the Data Structures and Algorithms teaching document (5652201) can help increase the students' knowledge since the students read the course content before entering the next lessons. This result was consistent with research on A Study of the achievement using teaching material in Education innovation and Information Technology for third-year students of Mahachulalongkornrajavidyalaya Ubonratchathani Campus (Tednard, 2014) – before the learning, the average was 23.59 and after the learning, it increased (average = 43.23). It was statistically different at the significance level of 0.05.

Thirdly, the result of students' satisfaction with the teaching document, was found that an overall aspect was at a high level ($\bar{X} = 4.54$) which was higher than the criteria of 3. Since there was no teaching document provided for this subject, the students had to search for additional knowledge and information as required by the teachers individually. The result was consistent with research on the Development and Efficiency of Design of Computer-Assisted Teaching Programs Teaching Document for 2nd Year Vocational Certificate Students, Sriwattana Business Administration Technological College (Phokaa, 2011). The result was found to be that the students were satisfied with the Design of Computer-Assisted Teaching Programs (4610109). An overall aspect was at a high level ($\bar{X} = 4.36$) and each aspect was also at a high level ($\bar{X} = 4.36$).

SUGGESTIONS

According to the students' satisfaction with the teaching document that answers the objective (4), it was found that the overall aspect of students' satisfaction was at the highest level ($\bar{X} = 4.54$) which is higher than the criteria 3. Particularly, the Aspect of Appropriate Amount of Content and Easy-to-Understand ($\bar{X} = 4.33$), each lesson should be adjusted to have the same amount

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of content and consistency for practical application. Also, the content should be consistent with the digital business models. Especially, during the COVID-19 pandemic situation, there should be adjustments to online learning activities for more effective learning achievement or higher efficiency and effectiveness index, which is more than 71 percent.

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